MODEL 801
POTENTIOMETRIC DC VOLTM

PLEASE RETURN TO LIBRARIAN
ORG. ~~6-7744~~ 6-8210 M.S. ~~27-14~~ 47-24
manual # 2

ELECTRONIC
TOOLS FOR
INDUSTRY

JOHN FLUKE MANUFACTURING CO., INC.
SEATTLE, WASH

RETURN TO #1
FLIGHT TEST EQUIPMENT

PLEASE RETURN TO LIBRARIAN
ORG. 6-7744 M.S. 27-14
6-8210 47-24
manual # 2

MODEL 801
POTENTIOMETRIC DC VOLTMETER
INSTRUCTION MANUAL

DUE FOR CALIBRATION
RETURN TO
R. B. SCHROEDER
F. T. MAINT. LAB.

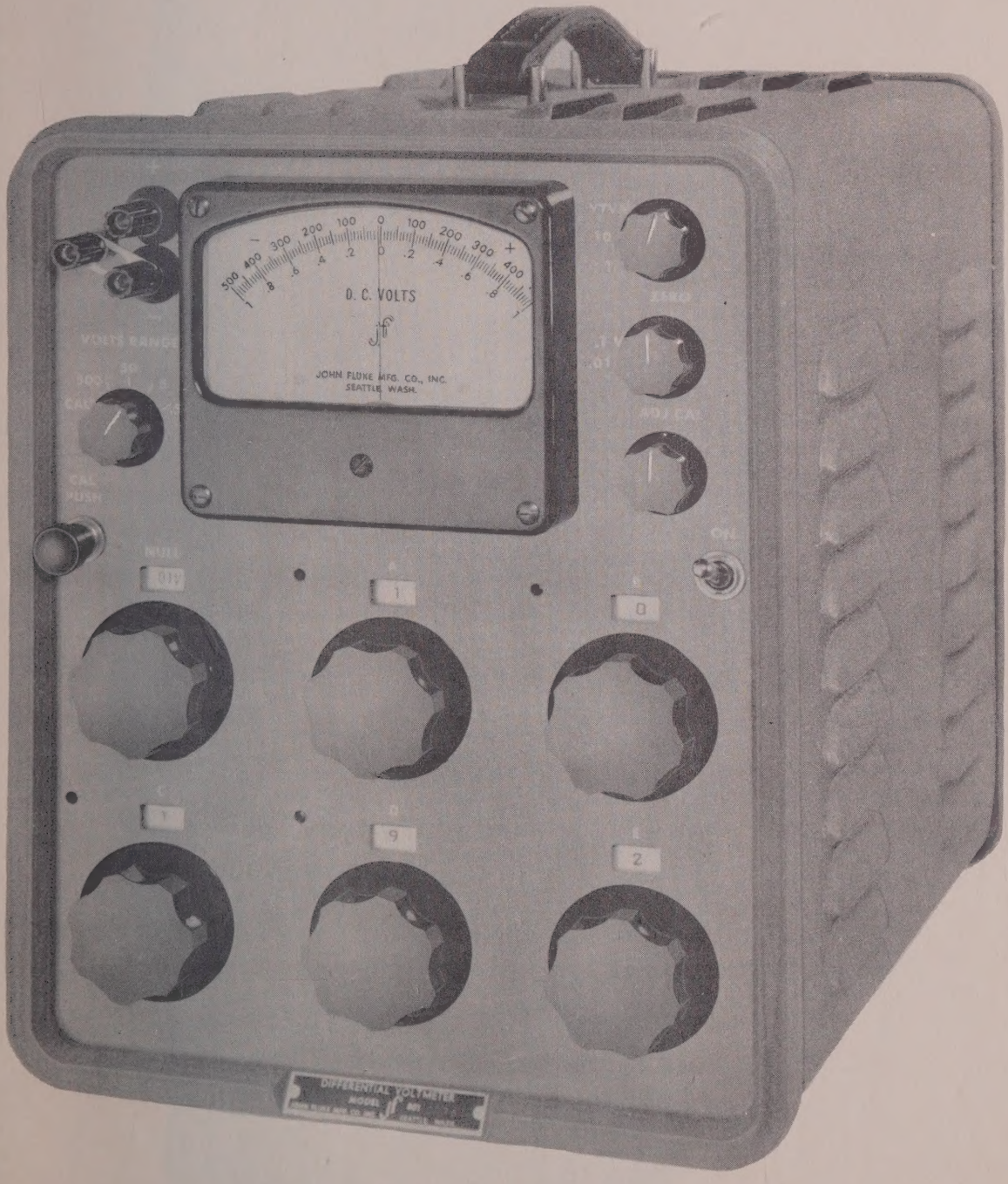
PLEASE RETURN TO LIBRARIAN
ORE. B-7744 M.S. 27-14
Manual

INSTRUCTION MANUAL FOR

jf MODEL 801

DIFFERENTIAL VOLTMETER

SERIAL NUMBER 3005 AND ABOVE


D. C. VOLTS
JOHN FLUKE MFG. CO., INC.
SEATTLE, WASH.

VOLTS RANGE
500
50
5
CAL
VOLTS NULL
10
1
.01
VTVM
ON
D.C. VOLTS
OP CAL
VTVM 10V IV
ZERO
IV .01V
ZERO
ADJ CAL
A
1
B
0
C
1
D
9
E
2

MODEL 801 PRECISION POTENTIOMETRIC DC VOLTMETER

TABLE OF CONTENTS

SPECIFICATIONS

INSPECTION AND INITIAL OPERATION ---------- Pg. 1

MEASUREMENT OF DC VOLTAGES ---------- Pg. 1

OBSERVATION OF VOLTAGE EXCURSIONS ---------- Pg. 2

USE OF NULL RANGES AS CONVENTIONAL VTVM ---------- Pg. 2

MEASUREMENT OF HIGH RESISTANCES ---------- Pg. 2, 3

NOTES ON MEASURING DC VOLTAGES ---------- Pg. 3, 4

EFFECT OF AC COMPONENT ---------- Pg. 4

MEASUREMENT OF NEGATIVE VOLTAGES ---------- Pg. 4, 5, 6

NOTES ON USE OF .1 & .01 VOLT NULL RANGES ---------- Pg. 6, 7

CIRCUIT DESCRIPTION ---------- Pg. 8 - 11

MAINTENANCE NOTES ---------- Pg. 12 - 14

TROUBLE SHOOTING HINTS ---------- Pg. 15 - 18

RECALIBRATION INSTRUCTIONS ---------- Pg. 19

RECOMMENDED CALIBRATION SET-UP ---------- Pg. 20

FIGURE 1 ---------- Pg. 21

MODEL 80 VOLT BOXES ---------- Pg. 1, 2

LIST OF REPLACEABLE PARTS ---------- Pg. 1 - 7

WARRANTY

CIRCUIT DIAGRAM

SHORT FORM CATALOG

MODEL 801 PRECISION POTENTIOMETER DC VOLTMETER

CONVENTIONAL VTVM SPECIFICATIONS:

RANGES	INPUT R	SCALES	*RANGES	INPUT R	SCALES
0 to ±500V	10 megohms	500-0-500	0 to ± 10V	10 megohms	10-0-10
0 to ± 50V	10 megohms	50-0-50	0 to ± 1V	10 megohms	1-0-1
0 to ± 5V	10 megohms	5-0-5	0 to ± .1V	1 megohm	.1-0-.1
0 to ± .5V	10 megohms	.5-0-.5	0 to ±.01V	1 megohm	.01-0-.01

ACCURACY: 4% on all ranges. *these ranges obtained by setting NULL knob to desired sensitivity with 5 voltage knobs set to 0.

PRECISION POTENTIOMETER SPECIFICATIONS

INPUT	*RECOMMENDED 801 RANGES RANGE SETTING	NULL SETTING		INPUT RESISTANCE (RES. PER VOLT OF INPUT) AT NULL	AT 1% OFF NULL
50-500	0-500	10-0-10	1-0-1	Inf.	100 meg 1000 meg
5-50	0-50	1-0-1	.1-0-.1	Inf.	1000 meg 1000 meg
.5-5	0-5	.1-0-.1	.01-0-.01	Inf.	1000 meg 10,000 meg
0-.5	0-.5	.1-0-.1	.01-0-.01	Inf.	1000 meg 10,000 meg

*Any null range may be used at any input voltage; recommended ranges are those most useful.

ACCURACY: ±.05% of input voltage from .1V to 500V.
±.1% of input voltage or ±.05MV whichever is greater, below .1V.
These accuracies obtain when recommended ranges are used.

RESOLUTION:

RANGE	DIRECT VIA DIALS		MAX. METER RESOLUTION ON MOST SENSITIVE RECOMMENDED NULL RANGE	
500	.01V	(10MV)	.005V	(5MV)
50	.001V	(1MV)	.005V	(500UV)
5	.0001V	(100UV)	.00005V	(50UV)
.5	.00001V	(10UV)	.00005V	(50UV)

STABILITY OF REFERENCE SUPPLY:
.01% for change in line voltage (105V to 130V)
.01% per hour after warmup (adjustable via front panel CAL control)

STABILITY OF METER ZERO:
4% of full scale for 20% change in line voltage
2% per hour after warmup (adjustable via front panel MTR. ZERO control)

CALIBRATION:
500 volt reference supply calibrated against built-in standard cell

INPUT POWER:
100-130 volts, 60 cycles, 60 watts

DIMENSIONS:
9-3/4" wide x 13" high x 14" deep - standard model
19" wide x 8-3/4" high x 16-3/4" deep - rack mounting model

FINISH AND WEIGHT: Smooth grey baked enamel. Grey baked wrinkle case.
cabinet model - 25 lbs.; rack mounting model - 28 lbs.

PRICE: $485 standard model; $485 rack mounting model; both FOB Seattle

JOHN FLUKE MFG. CO., INC., 1111 W. Nickerson St., Seattle, Wash.

MODEL 801
PRECISION POTENTIOMETRIC DC VOLTMETER

INSPECTION

This instrument has been thoroughly checked and tested before being shipped from the factory. Upon receipt of the instrument, inspect carefully for any damage which may have been incurred in transit. Reference should be made to the Warranty Section of this instruction manual for the procedure to be followed if any shipping damage has occurred.

INITIAL OPERATION

Connect the instrument to 117 volt 60 cycle source. Set VOLTS RANGE switch to CAL position, NULL switch to VTVM position, and all 5 voltage dials to zero. Throw toggle switch on right side of instrument to ON - meter should light up, and a buzzing noise should be heard to start; this comes from a 60 cycle chopper which is used to achieve stable dc amplification in the .1 and .01 volt null ranges. Allow instrument to warm up for approximately 5 minutes.

Calibrate the internal 500 volt reference source by pressing the CAL PUSH button with left hand while adjusting the ADJ. CAL. knob with the right hand for absolutely no deflection of the meter needle. Maximum accuracy is obtained with the Model 801 when this operation is carefully performed. Check for perfect calibration by pushing and releasing the CAL PUSH button and checking for no movement of the meter needle. When this operation is carefully performed, the reference supply will be set to 500 volts within .01%.

Adjust meter zero knobs. To do this, turn VOLTS RANGE switch to "500" position and leave NULL switch in VTVM position. Set meter needle on zero by adjusting "VTVM, 10V, 1V" knob. Turn NULL switch to 10V and then 1V positions - meter should remain on zero. Then turn NULL switch to .1V position and set meter on zero by adjusting ".1V, .01V" knob. Turn NULL switch to .01V position - meter should remain on zero. The instrument is now ready for use.

TO MEASURE DC VOLTAGES

Determine approximate value of unknown voltage. With VOLTS RANGE switch set to 500 position and NULL switch set to VTVM position, connect voltage to be measured to plus and minus binding posts. If meter reads to the left, reverse connections. If reading is less than 50 volts, set VOLTAGE RANGE switch to 50, in other words, set VOLTS RANGE switch to the lowest range which will give an on-scale reading. With the NULL switch in the VTVM position, the 801 functions as a conventional 4-range VTVM with 10 megohms input resistance on all ranges. It is accurate to better than 4% and serves to locate approximately the unknown voltage in the 0 to 500 volt spectrum.

Determine precise value of unknown voltage. Set the 5 voltage dials to the approximate voltage indicated on the meter. Be sure to observe the decimal lights. For example, if the VOLTS RANGE switch is set to the 5 volt position the decimal

light between the A and B knobs will be lit. If the meter indicates that the unknown voltage is 3.5 volts, set the A knob to 3 and the B knob to 5, leaving the C, D, and E knobs set on zero. Now turn the NULL knob to the 1 volt position (the 10 volt position may be skipped when measuring voltages of less than 50 volts) and adjust last 4 knobs for zero meter deflection. Next turn NULL knob to the .1 volt position and trim last 3 knobs for zero meter deflection. Finally, turn NULL knob to the .01 volt position and trim last 2 knobs for zero meter deflection. The unknown voltage may now be read directly from the 5 dials, accurate to .05% of the actual voltage.

TO OBSERVE EXCURSIONS OF A VOLTAGE ABOUT A NOMINAL VALUE

Set up the nominal voltage on the five voltage dials as outlined above and observe the excursions directly on the meter on one of the four null ranges. Use recommended null ranges where possible (see specification sheet). A right hand deflection of the meter needle indicates that the voltage under observation has increased above the nominal value by the amount indicated by the meter reading; a left-hand deflection indicates that the voltage has decreased by the amount indicated.

TO USE AS CONVENTIONAL VTVM ON THE FOUR NULL RANGES

In addition to the 500-0-500, 50-0-50, 5-0-5, and .5-0-.5 volt VTVM search ranges in the Model 801, four additional ranges are available. These are 10-0-10, 1-0-1 volts at 10 megohms input resistance and .1-0-.1, .01-0-.01 volts at 1 megohm input resistance. These four ranges are available by setting all five voltage dials to zero, connecting the voltage to be measured to the input binding posts and setting the NULL dial to the desired voltage range. The VOLTS RANGE knob is not used in this case and may be left in any position except CAL. Accuracy in these four additional VTVM ranges is ±4%.

TO MEASURE HIGH RESISTANCES (USE AS MEGGER)

The Model 801 may be used to measure resistances between 1 megohm and 500,000 megohms very quickly and conveniently. The unknown resistance can often be measured at any voltage between .01 and 500 volts to simulate actual operating conditions. Examination of the Model 801 circuitry and application of elementary circuit theory will produce the following equation for determining the value of an unknown resistance:

$$Rx = 10^7 \left(\frac{E}{Em} - 1\right) \text{ where}$$

Rx is the unknown resistance
E is the voltage setting of the 5 voltage knobs
Em is the meter reading on the appropriate scale (either 10-0-10 or 1-0-1) as determined by the NULL switch setting
10^7 is the input resistance of the VTVM in the 10 and 1 volt null ranges

1. To measure a high value resistance set the VOLTS RANGE switch to 500 and NULL knob to either 10V or 1V position. Zero meter by means of "VTVM, 10, 1" knob.

2. Connect the unknown resistance between the plus and minus terminals. Leave link connected between - and G terminals. Avoid the use of long twisted leads since the Model 801 can easily measure the leakage resistance of the insulation on such leads. It is best to use very short isolated leads. Connect the negative terminal to the grounded side of the resistance under measurement (if one side happens to be grounded) or to the common-ground point if in a "floated" circuit.

3. Now adjust the five voltage controls to any desired value between .01 and 500 volts or to any voltage which allows convenient reading of the meter (that is, produces a reasonable, easily read meter deflection - say, 10% of full scale). The maximum resistance that can be used is approximately 500,000 megohms. With this resistance connected to the input posts, NULL switch set to 1V position and the five voltage dials set to 499.910 the meter will read .01 volts to the left of zero. (All resistance measurements cause a meter left deflection.)

4. Read the meter, the voltage dials and the NULL switch setting and substitute these values in the equation given. Compute the value of the unknown resistance.

5. For rapid measurement of resistances up to 500 megohms without use of the formula, merely set NULL switch to the 10V position, adjust the 5 voltage dials for full scale meter deflection and subtract 10 from the reading of the voltage dials. This is the value of the unknown resistance in megohms.

6. For rapid measurement of resistances up to 5,000 megohms without use of the formula set NULL switch to the 1 volt position and adjust the 5 voltage dials for full scale meter deflection. Subtract 1 from the reading of the voltage dials and multiply the difference by 10. This is the value of the unknown resistance in megohms.

NOTES ON MEASURING DC VOLTAGES

Reference to the Model 801 specification sheet will show the recommended VOLTS RANGE switch settings for obtaining maximum accuracy from the instrument. Since the accuracy of the Model 801 is governed chiefly by the linearity of the Kelvin-Varley five-dial attenuator, and since the highest accuracy resistors in the attenuator are used in the A decade (all resistors matched to ±.005%), next highest accuracy in the B decade (all resistors matched to ±.0125%) etc. it is obviously best to use these most accurate decades at all times.

Therefore, when measuring a voltage of 3.52 volts for example, do so by setting the VOLTS RANGE switch to the 5 position and using all 5 knobs rather than setting the VOLTS RANGE switch to the 500 position and using only the last 3 knobs. Better absolute accuracy will thus be obtained as well as two additional figures in the readout.

Reference to the Model 801 specification sheet will also indicate certain recommended NULL ranges to be used with each setting of the VOLTS RANGE knob.

The .01 volt NULL range is not recommended for use in the 50 to 500 volt range for three reasons. First, unless the voltage being measured is an even multiple of .01 volts, it will be impossible to obtain a null, since the last voltage dial is calibrated in .01 volt steps when operating in the 500 volt position of the VOLTS RANGE switch; one step of this switch causes full scale meter deflection with NULL switch at .01V. Second, it is unlikely that a voltage of say 450 volts will be stable to 10 millivolts, and third, the Model 801 will tend to meter the regulation of its own 500 volt reference supply. The regulation of this reference supply is approximately .01% for a 30% change in line voltage. While this figure is more than adequate for the instrument when used in recommended fashion, it may cause some meter rattle if the line voltage fluctuates badly while the instrument is used in the .01 volt null range for metering excursions at several hundred volts.

EFFECT OF AC COMPONENT

The Model 801 employs four null ranges. Two of these, the 10 volt and 1 volt ranges, employ a cathode follower type vacuum tube voltmeter circuit. This type of VTVM is not particularly sensitive to an AC component in the DC being measured. Accordingly, an AC component of several volts may be present on the DC signal being measured and the 801 will still read within specs as long as only the 10 and 1 volt null ranges are used. This not true with the .1 and .01 volt null ranges. Here a chopper amplifier precedes the cathode follower VTVM. The chopper contacts are driven at power line frequency, 60 cycles. Any signal appearing at these contacts, whether DC or AC, is passed to the grid of the first amplifier stage during the time the contacts are open. It is implified and rectified by the back contact of the chopper on alternate half cycles. Obviously any AC which appears at these contacts will appear as DC after amplification and rectification just as a DC off-null signal would.

A two section low pass filter comprised of R123, R124, C109, and C110 is used at the input to reduce any AC present on the DC being measured. This filter has an attenuation ratio of 330 to 1 at 60 cycles. A one-half volt 60 cycle component will therefore be reduced to slightly over one millivolt. This may still cause a reading of as much as 10% of full scale when operating in the .01 volt null range however, and may be positive or negative depending on the phase relationship between the AC component and the chopper driving coil source. If large AC components are present and the chopper null ranges must be used, additional filtering may be required. If the AC is of a single frequency, a twin T filter is extremely effective and has the advantage of low total series resistance. If the AC is of variable frequency, an ordinary low pass filter may be used. In either case the capacitors used should be high quality units of extremely high leakage resistance.

MEASUREMENT OF NEGATIVE VOLTAGES

Voltages which are negative with respect to ground may be measured with the 801 as well as the more commonly encountered positive variety. However, when the 801 positive binding post is connected to the G post (metal case), either at the posts themselves or at the source under measurement, and the negative

side of the 801 is connected to the "hot" side of the source, certain circuit conditions are changed and must be taken into consideration.

First, a .1 MFD capacitor (C7) is connected directly across the source under measurement. In certain circuits this capacitance may affect the source EMF. If this capacitor were removed there would still be considerable capacity, in the form of transformer winding capacitance and wiring strays, between the 801 input posts.

Second, a small 60 cycle signal appears between the 801 input posts (across C7) when the shorting link is connected between the plus and G posts. This comes about by slightly unbalanced transformer high voltage winding - to core capacitances. By careful transformer design this signal has been kept to less than 50 millivolts. Mevertheless, it may still affect the 801 reading and/or the DC voltage under measurement under the following conditions:

1. If the most sensitive null range (.01 volt) is being used, a fraction of a millivolt will get through to the chopper contacts and appear as a DC off null reading. If the DC voltage under measurement is quite small, some inaccuracy may result.

2. If the source under measurement contains unilateral conducting elements, such as the diodes used in limiter circuits, together with high internal resistance, this spurious 60 cycle signal may be rectified by these diodes and appear across the source as DC, which either adds to or subtracts from the true EMF of the source. The 801 will of course read this false voltage. Therefore, if the source under measurement does contain diodes, choppers, or other unilateral circuit elements, some additional filtering may be necessary to prevent this spurious 60 cycle signal from reaching the voltage source under measurement. A twin T is extremely effective and will reduce the signal to a few millivolts of 180 cycles, which can be handled with a simple low pass filter if still objectionable. Or one or more sections of low pass filter alone may be used between the 801 and the source. The twin T has the advantage of low series resistance. This is only important if off-null voltageexcursions are being observed. Since the chopper input resistance is 1 megohm, series resistance of greater than 100K may cause objectionable full scale off-null error. At null, of course, the input resistance of the 801 is infinite, so the filter resistance has no affect.

Third, connecting the shorting link from the + post to G post leaves C7, a .1 MFD capacitor, connected across the input. With nothing connected to the input posts and the NULL switch in the more sensitive null ranges, the meter will flop around wildly as the settings of the five voltage dials are changed. This comes about because C7 charges and discharges to the level set on the 5 voltage dials, through the input resistance of the VTVM channel (10 megohms for the 10 and 1

volt ranges, and 1 megohm for the .1 and .01 volt ranges). Since the entire change in voltage appears across the R in an RC current at the instant the change occurs, the meter needle will pin hard at the instant the voltage dials are changed (providing the change is greater than that required for full scale meter deflection). The solution is obvious - don't tweek the voltage dials with the null switch in other than the VTVM position when the input is unterminated, since no useful purpose is so served anyway.

NOTES ON USE OF .1 VOLT AND .01 VOLT NULL RANGES

Use care when operating in the .01 and .1 volt null ranges. Do not inadvertently apply several hundred volts to the instrument with the VOLTS RANGE switch set in the .5 volt position as the chopper will be seriously overloaded. While the chopper used in the Model 801 is an extremely rugged unit whose contacts are rated 100 volts maximum, repeated applications of several hundred volts will have an adverse effect on it.

Do not check calibration without first disconnecting the voltage being measured from the plus binding post. This is particularly important when operating in the 5 and .5 volt ranges where the NULL switch is usually set in the .1 or .01 volt ranges.

The reason for this is that when the VOLTS RANGE switch is rotated from the .5 position counterclockwise back toward the CAL position, the voltage developed between the minus binding post and the output of the 5-dial divider (rotor of "E" switch) is multiplied by 10, 100, and 1000 as the VOLTS RANGE switch successively passes through the 5, 50 and 500 positions on the way back to the CAL position. This voltage connects to the negative bus of the VTVM channel, up through the input divider resistors to the plus input binding post, thence through the internal resistance of the voltage being measured to the minus binding post, through the 5-dial divider resistors and back to the negative bus of the VTVM channel. If a .45 volt unknown signal were being observed with VOLTS RANGE and NULL switches in .5 and .01 volt positions respectively, rotating the VOLTS RANGE switch back to check calibration would momentarily impress 450 volts across this network of dividers and voltage sources. Reference to the circuit diagram will show that current through the voltage source being measured is limited by the 1 megohm resistance of R130 and R131, while current through the chopper contacts is limited by this 1 megohm plus the 2.6 megohms resistance of R123 plus R124 plus R125 which resistors comprise the input filter to the chopper amplifier. Thus current through the voltage source under measurement would be limited to 450 microamperes, while current through the chopper contacts would be limited to around 120 microamperes. While this probably would not damage either the chopper or the unknown voltage source, it should definitely not be done. If it is necessary to check calibration of the internal reference supply, remove the lead connecting the voltage being measured to the plus input binding post before rotating the VOLTS RANGE knob.

If a large voltage is accidentally applied to the chopper amplifier, either by having the 5 voltage dials set much too low or much too high with respect to

the voltage being measured, or by checking calibration without first disconnecting one lead from the voltage under measurement as discussed above, it may be found that the meter will not come back to zero in the absence of any input signal. This is caused by temporary polarization of the two .22 mfd capacitors C109 and C110 which comprise part of the filter at the input of the chopper emplifier. These may charge to a relative high voltage and may require some time to discharge completely (a 1 millivolt charge on these capacitors will cause the meter to deflect 10% of full scale when using the .01 volt null range). The quickest way to restore the instrument to normal operation is to remove it from the case and connect clip leads across both capacitors. Leave these connected for a few seconds, then remove and replace instrument in case, after which operation will be found normal. Usually this is not necessary and the capacitors will discharge completely in a matter of minutes.

With normal care, the Model 801 will give excellent results with minimum maintenance, aside from occasional tube replacement and replacement every two years of the small mercury bias cell B1 used in the chopper amplifier.

MODEL 801

PRECISION POTENTIOMETRIC DC VOLTMETER

CIRCUIT DESCRIPTION

The Model 801 Precision Potentiometric DC Voltmeter operates on the potentiometer principle wherein an unknown voltage is measured by bucking it against an adjustable known voltage and the difference read on a sensitive null detector. When zero displacement current flows in the null detector, the unknown voltage is exactly equal to the known voltage and the impedance presented to the unknown voltage source by the known voltage source and null detector is infinite.

The circuit consists of six main elements which are:

1. A super regulated, extremely stable 500 volt reference source.

2. Means for setting this reference source to 500 volts within ±.01%.

3. A range switch for dividing the 500 volts down to three lower reference voltages of 50, 5 and .5 volts.

4. A calibrated 5 decade Kelvin-Varley precision attenuator for dividing the reference voltage down to the exact level of the unknown voltage.

5. A calibrated multi-range VTVM which is used both as a conventional VTVM for determining the approximate value of the unknown voltage and also as a calibrated null detector for measuring the difference between the unknown voltage and the known voltage derived from the 5 decade calibrated attenuator.

6. Appropriate attenuators for reducing the signal input to .5 volt maximum for the 4 VTVM ranges and the first 2 null ranges (10V and 1V) and to .01 volt maximum for the last 2 null ranges (.1V and .01V).

Element 1 consists of an unregulated 900 volt DC supply (V1, R1, C1, and C2), a pre-regulator delivering 625 volts at 1% regulation (V2, V3, V5, and associated components), and a super-regulator delivering 500 volts at .01% regulation (V4, V6, V7, V8, and associated components). The super-regulator uses the highly stable type 5651 reference tubes, a carefully balanced differential amplifier as the equating element, and precision wirewound resistors in the sampling circuit. The stability of this 500 volt supply is better than .01% per hour after a short warm-up period.

Element 2 consists of P1, S7, a standard cell B2, a precision wirewound divider (R15, R19, R16, and P2) across the 500 volt supply from which is derived a voltage

exactly equal to the EMF of the particular standard cell used when the output is exactly 500.00 volts, a 50-0-50 microamp meter M1, and VOLTS RANGE switch sections S8C and S8D for connecting the meter between the standard cell and 1 volt sample of the 500 volt output.

To calibrate, S7 CAL PUSH switch is pushed and P1 "ADJ CAL" knob is rotated until there is no deflection of the meter needle.

Element 3 is comprised of S8A and S8B, precision wire-wound resistors R142 through R148, rheostats P3, P4, and P5, and the 200,000 ohm 5-dial Kelvin-Varley type attenuator since this attenuator always shunts the lower portion of the range divider string (portion between switch S8B rotor and the negative bus).

Element 4 is made up of S1, S2, S3, S4, S5, and associated matched precision wire-wound resistors, R20 through R68. The resistors on the A switch are matched to be within ±.005% of each other; those on the B switch to within ±.012%, those on the C, D, and E switches to within ±.025%. If any of the resistors in this dial attenuator become defective, send resistor value and serial number of the instrument to John Fluke Mfg. Co., Inc., where a record is kept of the exact values used in each instrument shipped. In this way a replacement can be obtained which will not upset the matching of the other resistors on the particular switch.

Element 5 consists of a cathode follower type VTVM, V104 and associated components R109, R110, R111, C102, P101 (meter zero control for VTVM, 10V and 1V ranges), M1, and VOLTS RANGE switch sections S8C and S8D for switching the meter from the CALIBRATE function to the VTVM function. This VTVM has a basic full scale sensitivity of .5 volt; that is, a .5 volt dc signal applied between pin 2 of V104 and the 0 volt bus of the voltmeter channel, with everything to the right of R111 cast loose, will cause the meter to deflect full scale right or left, depending on whether the signal is positive or negative respectively (pin 2 with respect to 0 volt bus).

In order to provide the more sensitive null ranges (.1 volt and .01 volt) a chopper amplifier is used to amplify the signal by a factor of 5 or 50 respectively (gain of the amplifier is constant; input signal is attenuated by factor of 10). This amplifier consists of V100, V105, a break-before-make type single pole double throw 60 cycle chopper, and associated components, R112 through R125 and C103 through C112. Both heater and plate voltage on both the cathode follower VTVM tube and the two chopper amplifier tubes are regulated. V101 is an Amperite regulator tube for maintaining heater voltage at 6.3 volts ±.2 volt in the face of 20% line voltage change. V102 and V103 are cascaded voltage regulator tubes which procide 105 volts at better than .1% regulation and less than 2 millivolts ripple to V100, V104, and V105.

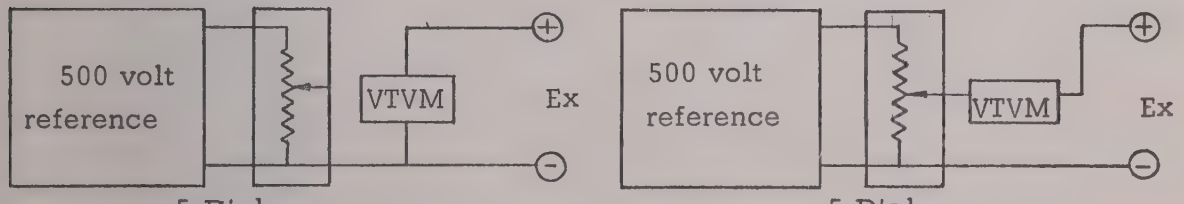
The gain of the chopper amplifier is stabilized by a feedback network consisting of C106, R119, P103 and R122 and is so adjusted that a 10 millivolt dc signal

applied between the top of R123 and the 0 volt bus of the voltmeter channel will appear as a .5 volt dc signal across C103. R123, R124, C109, and C110 serve as a 2-stage low-pass filter for removing any unwanted ac from the dc signal input. The armature and upper contact (pin 6) of the chopper converts the dc signal to square wave ac and the two halves of V100 amplify it. V105 serves as a phase inverter so that a positive going input signal will, after rectification, appear as a positive going dc voltage and cause an upscale meter reading. (When the unknown voltage is larger than the voltage set up on the 5 voltage dials, the meter reads upscale). After amplification and phase inversion, the ac output signal is synchronously rectified by the armature and lower contact (pin 1) of the chopper. R112 and C103 form a low-pass filter for removing the ripple component from the rectified signal; the resulting dc is then applied to the cathode follower VTVM. The purpose of the chopper-amplifier section, of course, is attainment of stable, drift free dc amplification for signals in the microvolt to millivolt region.

Element 6 consists of the appropriate sections of VOLTS RANGE switch S8 and NULL switch S9, together with their associated resistors R128 through R139. VOLT RANGE switch section S8E and resistors R136 through R139 divide the unknown voltage down to .5 volt from either 500, 50, or 5 volts depending on the setting of the switch. VOLT RANGE switch section S8F and resistors R133 through R135 are used to maintain the resistance between input grid of VTVM (pin 2 of V104) and negative side of voltmeter channel constant at 11 megohms.

In order to use the instrument as a straight VTVM, the negative input binding post is connected directly to the negative side of the voltmeter channel via NULL switch S9A; the positive input binding post is connected to the VOLTS RANGE switch divider via NULL switch S9B and the VTVM input grid is connected to the output of the VOLTS RANGE switch divider via NULL switch S9E. This is illustrated in block diagram below.

In order to use the instrument in the differential mode, the entire voltmeter channel is floated between the output of the 5-dial attenuator and the positive input binding post. The block diagram below illustrates this.



5 Dial Attenuator STRAIGHT VTVM

5 Dial Attenuator DIFFERENTIAL VTVM

This is effected via NULL switch sections S9A and S9B. NULL switch sections S9B and S9C serve to attenuate the 10 volt or 1 volt out-of-balance signal to .5 volt for application directly to the cathode follower VTVM input grid (pin 2, V104). In the last two positions of the NULL switch the .1 volt and .01 volt

out of balance signals are attenuated to .01 volt for application to the chopper amplifier. NULL switch section S9D serves to switch the output of the NULL attenuator either straight into the VTVM (in 10 and 1 volt positions) or into the chopper amplifier (in .1 and .01 volt positions). R126 and R127 are used to maintain the resistance between the input grid of VTVM (pin 2 of V104) and negative side of voltmeter channel constant at 11 megohms.

Capacitor C111 is a high grade polystyrene 1 mfd 200 volt capacitor used to eliminate the hash picked up by the wirewound resistors in the 5 dial attenuator, and provide a return path to the hegative binding post for the chopper input filter (C109, C110, R123, R124).

Screwdriver adjust control P104 is adjusted so that full scale meter deflection results when exactly .5 volt is applied to the input binding posts with NULL switch set to VTVM position and VOLTS RANGE switch set to .5 volt position. Screwdriver adjust control P103 is adjusted <u>after</u> P104 has been adjusted. It is set so that full scale meter deflection results when exactly .01 volt is applied to the input binding posts with NULL switch set to .01V position, VOLTS RANGE switch set to any position except CAL, and all 5 voltage dials set to zero. A simple method of making these adjustments is to set the VOLTS RANGE switch to the 5 volt position, NULL switch to 1 volt position, and A switch to the 1 position (other 4 voltage switches must be set to 0). Next connect a resistor of approximately 40,000 ohms across plus and minus binding posts (this approximates the resistance of the 5 dial divider when dials set at midpoint) and adjust P104 for full scale left deflection. Then set "C" switch to 1 and other 4 voltage switches to zero, leaving 40,000 ohm resistor connected across input posts, adjust P103 for full scale left meter deflection. Slide instrument back into case and recheck meter deflection, since the chopper amplifier is subject to stray fields and this adjustment is one which must be made with instrument withdrawn part way out of case.

This consludes the circuit description. Should trouble accur, an orderly step by step servicing procedure should locate the source. If trouble cannot be isolated, write us giving full details of the difficulty and include serial number. On receipt of this information we will send service data or shipping instructions.

<u>CAUTION</u>: IT IS RECOMMENDED THAT THE PLUG TO THE STANDARD CELL BE REMOVED WHEN TROUBLE SHOOTING TO PREVENT ACCIDENTAL SHORTING AND DAMAGING OF THE CELL.

MAINTENANCE NOTES

TUBE REPLACEMENT. All tubes used in the Model 801 are, with the exception of the Amperite type 9-7, common receiving types. Only two of the 14 tubes used are at all critical - these are V6 in the 500 volt reference supply and V104 in the VTVM channel. Should replacement of these be necessary, the following procedure should be followed to insure optimum performance of the instrument. We recommend replacement of these two with factory pretested tubes.

V6 - this tube is a high mu dual triode, type 12AX7, used as a differential amplifier. This connection insures maximum stability and minimum effects from line voltage change. Some tubes have poor balance between halves, however, causing poor regulation against line voltage. Check for this by allowing 5 minutes for tube to heat and then varying line voltage from 100 to 130 volts and checking reference supply output voltage with another Model 801 or 800. The 500 volts must not change by more than 50 millivolts (.01%) over this range of line voltage. If regulation exceeds this figure, discard tube in favor of another. Such discards may work very well for V100 in the chopper amplifier since it is an AC coupled amplifier not dependent upon the DC tube characteristics for proper performance.

V104 - this tube is a medium mu dual triode used in a cathode follower type VTVM circuit. The two requirements of V104 for satisfactory performance are good balance between halves and low grid current. These can be checked by setting RANGE switch to 500, NULL switch to 1V and all 5 voltage knobs to zero. Allow a few minutes for tube heating and then check for ability to zero meter. At zero, the top meter zero knob pointer should lie within $\pm 90^{\circ}$ of vertical. If outside these limits remove tube and try another. If okay, vary line voltage from 105 to 130V and check stability of meter zero. Meter should not offset more than ±4% (2 small scale divisions). If it does, check the heater voltage to determine whether the Amperite 9-7 ballast tube is okay. Heater voltage at 117 volts line should measure between 5.5 and 6.5 volts and should change less than .5 volt for a line voltage change from 105 to 130 volts. If outside these limits, replace. If the ballast tube is functioning properly but the meter offset exceeds 2 small scale divisions for a 30 volt change in line voltage, discard V104 in favor of another with better balance.

To check for excessive grid current in V104, set RANGE knob to 500, NULL knob to 1V, the five voltage knobs to zero and line voltage to 117 volts. Zero meter and then short the input binding posts. Meter offset must not exceed 1/4 of one small scale division - if it does, replace V104. Shorting the input posts changes the resistance in the grid circuit of the right half of V104 from 10 megohms to 8 megohms. Assuming the small grid current to be constant (which is not strictly true) this changed grid resistance appears as a change in grid voltage which causes a small meter offset to the left. The average Amperex 12AU7 produces offset of from 0 to 1/2 of one small scale division. It is important that this offset be kept to a minimum in order that slight errors not result from measuring EMF's with widely varying internal

resistances. This is not error due to external circuit loading since the 801 at null presents infinite resistance to the external circuit. Rather it is error due to shunting of the normal 10 megohms VTVM grid circuit resistance by the internal resistance of the voltage source under measurement.

The John Fluke Mfg. Company's sales representative in your area maintains a stock of aged replacement tubes selected for optimum performance in these two critical spots - V6 and V104. If replacement becomes necessary, contact him and advise tube type required. This is usually simpler than selecting tubes from stock on hand.

Replacement of V100, the 12AX7 chopper amplifier tube should be made with one which is not microphonic. The Westinghouse type 12DF7 is a low microphonic version of the 12AX7 and may be used if desired. A microphonic or otherwise noisy tube may cause meter rattle in the .01 and .1 volt null ranges. Another possible source of meter rattle in these ranges is a defective type OB2 (V103).

Should the ballast tube V101 burn out or otherwise fault, it may, in an emergency, be replaced with a 10 ohm, 10 watt resistor. Remove tube and solder resistor across pins 2 and 7 on the printed circuit board. Voltage at the heaters of the tubes on the VTVM board should then run around 6 volts at 117 volts line voltage. If a resistor is not available there is a 6.3 volt transformer tap taped back to the bundle of transformer leads coming out the right side of transformer (VTVM printed circuit board side). This is a yellow sleeved lead. Unsolder the green lead (15 volt end of this winding) and tape it back out of the way using plastic tape since any leakage from any point on the VTVM board to chassis will cause meter offset. Solder the yellow lead to the board in place of the green lead and jumper pins 2 and 7 of the V101 socket. This runs the tubes on the VTVM board at 6.3 volts unregulated. As soon as replacement is available, restore circuit to its original condition <u>being sure to remove the jumper from across pins 2 and 7 of V101.</u> Failure to do this will almost certainly damage the tubes and chopper since they will be running at 15 volts instead of 6.3 volts.

2. STANDARD CELL AND BIAS CELL REPLACEMENT. The standard cell, B2, used in the Model 801 is an Eppley type MIN 1. This is a miniature low hysteresis unit which has excellent long term stability and negligible temperature hysteresis. (Hysteresis is a temporary increase in EMF immediately following a decrease in temperature - this effect should not be confused with temperature coefficient). Under normal conditions this cell should last from 8 to 15 years. End of life is usually heralded by a marked increase in temperature hysteresis effect. That is, reading errors in excess of .05% will result when the same voltage is read with the 801 hot and cold. Should replacement of the cell become necessary for any reason, the instrument must be recalibrated (basic 500 volt range only), since the EMF of different cells may be different by as much as .05% and each instrument is calibrated to its own particular standard cell. Refer to

the recalibration instructions for this. Nominal EMF of a new Eppley type MIN I cell at average room temperature is 1.0193 volts.

Do not subject the standard cell to below freezing temperatures. The electrolyte will freeze at -17°C and operation below 0°C is definitely not recommended. The life of the cell will be greater if the 801 is not operated at elevated temperatures. The 8 to 15 year figure holds for operation of the instrument in normal room temperature ambients.

The mercury cell B1 in this instrument is used soley as a source of tube grid bias voltage. It is located on the smaller of the two printed circuit boards and should last from 2 to 4 years since no current is drawn from it. Replacement should be made when its voltage falls below 1.2 volts measured directly across the cell terminals. A defective cell is often the cause of inability to zero the meter by the .1, .01V MTR zero control.

GENERAL CLEANING. The Model 801 is extremely sensitive to the slightest amount of electrical leakage from the VTVM channel, particularly the input grid of V104 (pin 2) and all its associated wiring, to the negative side of the input. Leakage resistance of 40,000 megohms between this grid circuit and the negative input will cause a 10% left meter deflection in the 1 volt null range when voltage dials are set to 400 volts; lower values of leakage resistance will cause larger no signal meter deflection. An analysis of the 801 circuitry will show that it meters its own internal leakage resistance. Therefore, the instrument should be cleaned occasionally to remove dust and foreign matter, particularly from the two Plexiglass strips which insulate the VTVM chassis from the metal frame of the instrument, the positive binding post and the ceramic NULL and RANGE switches. Blow the instrument out with a low pressure air hose (be sure air is dry) and wipe strips off with a clean dry rag. If necessary, wipe the Plexiglass strips with a rag saturated in Metriclene Solvent M-4 (manufactured by the John B. Moore Corp., Nutley, New Jersey). This is a high grade, non-toxic solvent for use on delicate electrical equipment. Many other solvents have very poor electrical properties and leave a residue which might be slightly conductive. Switches may be washed using a small stiff bristled brush dipped in Metriclene. After washing, the ceramic surfaces must be recoated with a 10% solution of Dow Corning 200 Fluid (100 viscosity grade) in Metriclene. This prevents moisture collecting across the ceramic surfaces.

If the instrument is stored for a considerable period of time in a hot humid atmosphere considerable leakage may be noted upon initial operation. This is evidenced by large meter offsets in the null ranges as the voltage dial settings are increased. This usually clears up as the instrument warms up and dries out, if not remove from case and wipe above mentioned surfaces with clean dry cloth.

If necessary to clean the binding post insulators, do not use Metriclene. Use only pure denatured alcohol and a clean cloth, since the insulator material is slightly solvent in Metriclene.

TROUBLE SHOOTING HINTS

. Excessive drift in 500 volt reference supply - this is evidenced by having to recalibrate the unit every five or ten minutes for an hour or more. Trouble is usually a defective reference tube V7 or V8, or a faulty equating tube V6. A leaky feedback capacitor C6 may cause either drift or unstable output.

. Excessive drift in VTVM - drift should stop after a few minutes operation. If it persists, replace V104.

. Inability to calibrate instrument - if meter deflection cannot be reduced to zero by following step 2 under "Initial Operation" trouble is in one of following:

A. Either R17 or R18 has shifted, making it impossible to bring output of super-regulator to 500V. Replace out of tolerance unit.

B. V7 and/or V8 have aged to the point where their running voltage is too low. Replace them if this is the case. Their running voltage should lie between 85 and 87 volts. Screwdriver adjust control P6 may be adjusted to bring the front panel CAL ADJ control to the approximate center of its rotation at the point meter deflection has been reduced to zero. Also, a precision wire-wound resistor may be added, where jumper X is used (forward edge of large printed circuit board) to compensate for reference tubes with low running voltages or to trim the string in the event replacement of R17 and/or R18 must be made with values other than those specified. Only do this in an emergency and never use anything but precision wire-wound resistors wound with either Evanohm, Karma, or Manganin alloys. Under no conditions attempt replacement with ordinary power resistors, Nichrome resistors, carbon or deposited carbon resistors, or metal film resistors. This statement applies to every single precision wire-wound resistor in the instrument.

C. One of the three wire-wound resistors in the standard cell sampling string has changed value. These are R15, R16, and R19. If replacement of any of these is necessary the instrument must be recalibrated. See recalibration instructions.

D. The standard cell may have shifted value very badly. It should measure between 1.0190V and 1.0196V. Use only a Model 801 or a Leeds & Northrup type K potentiometer (or other similar potentiometer) to make this measurement. DO NOT USE A VOLTOHMMETER. If replacement of cell is necessary instrument must be recalibrated. See recalibration instructions.

E. Failure of either the rectifier filter (V1, C1, C2), the super-regulated power supply (V4, V6, V7, V8) or the pre-regulator (V2, V3, V5). Output if the rectifier filter should run approximately 900 volts at a line volt-

age of 117 volts. Output of the pre-regulator should run 610 to 640 volts and be regulated to better than 1% over range of 100 to 130 volts line. Output of the super-regulator must obviously be 500 volts and should have a range of adjustability of at least 5 volts either side of 500. Regulation must be .01% or better over range of 100 to 130 volt line.

4. Error in excess of specified values - this is caused either by the instrument being out of calibration or by a defective resistor in the 5-dial Kelvin-Varley voltage divider.

   A. A quick check to determine whether this divider is okay consists of setting the 5 voltage dials to 400.00 and applying an EMF from an extremely stable high resolution DC power supply, such as the John Fluke Models 301C, 406, or 407. Adjust supply until a null is obtained in the 1 volt range. Then remove voltage from input and reset the 5 voltage dials to 399.9^{10}. Reconnect the 400 volts to the instrument again with NULL switch in 1V position. Meter should null within 80 millivolts (.02%). Repeat this check applying 50 volts and setting up 50.00 first on the voltage dials and then 49.9^{10}. Difference in the two readings must be less than ±25 millivolts (.05%).

      Non-linearity is usually traceable to one defective wire-wound resistor on one of the five switches. Since these are matched units the drops across each resistor on a particular switch should lie within .01% of each other on X100, .025% on X10, and .05% on the other three. If replacement of any resistor is necessary wire serial number of instrument to factory where a stock of matched replacements is maintained.

   B. To determine whether instrument is still in calibration proceed as follows:

      Since this is a four range instrument, there are four calibration adjustments. The basic adjustment concerns the 500 volt range and employs a screwdriver adjust rheostat P2. It affects not only the 500 volt range but each of the other three ranges as well. The other three ranges, 50V, 5V and .5V, employ individual screwdriver adjust rheostats P3, P4, and P5, respectively, which are completely independent adjustments. That is, adjustment of any one of the three has no effect on the other two ranges, nor on the basic 500 volt calibration.

      Obviously then, the first range to check is the 500 volt range. If this is out of calibration then all three of the lower ranges will also be out of calibration. To check the basic 500 volt range calibration perform the calibration operation as outlined in paragraph 2 under INITIAL OPERATION. Then apply a KNOWN 500 volts - this voltage

must be accurate to .01% or better - to the instrument and measure it. It must read between 499.90 and 500.10 volts (±.02%). If outside these limits follow recalibration instructions.

NOTE: A 500 volt EMF accurate to .01% is extremely difficult to obtain. If there is any doubt in your mind as to the accuracy of your 500 volts, do not use it. Instead, contact our field representative in your area. Most of them have in their repair stations a John Fluke approved precision calibration set-up and therefore can perform this important check to the accuracy required. Refer also to the RECOMMENDED CALIBRATION SET-UP section of this manual.

If the error appeared in one of the three lower voltage ranges and the basic 500 volt calibration was found to be off and recalibration performed, recheck the lower range to see whether the recalibration of the basic 500 volt range corrected the error. If not, proceed as follows: Let us assume the error appears in the 5 volt range. Set the VOLTS RANGE knob to the 5-volt position, apply a KNOWN 5 volts - this voltage must be accurate to .01% or better - to the instrument and measure it. It must read between 4.999 and 5.001 volts (±.02%). If outside these limits follow recalibration instructions.

NOTE: Any EMF accurate to .01% is extremely difficult to obtain. If there is any doubt in your mind as to the accuracy of your 5 volts, do not use it. Instead, contact our field representative in your area. Most of them have in their repair stations a John Fluke approved precision calibration set-up and therefore can perform this important check to the accuracy required. Refer also to the RECOMMENDED CALIBRATION SET-UP section of this manual.

5. Error in the VTVM readings - if meter reads off in all four VTVM ranges as well as the 10 and 1 volt null ranges, adjustment of P104 is probably required. This is the upper screwdriver adjust potentiometer on the smaller printed circuit board. If the error lies in only certain ranges the trouble is probably in one of the dividers - S8E for the VTVM ranges and S9C for the null ranges.

   If there is error in the .1 or .01 volt null ranges the trouble is either a defective 12AX7 chopper amplifier tube V100 (if both ranges are off), or the NULL divider in switch section S9C. Also check adjustment of P103.

   NOTE: DO NOT POKE AROUND THE SWITCH DIVIDERS WITH A SHARP POINTED TOOL. IF A DEPOSITED CARBON RESISTOR COATING IS SCRATCHED DEEPLY ENOUGH, THE RESISTOR WILL OPEN UP.

6. Meter needle offsets to the left as voltage dials settings are increased (NULL switch in 1 volt position, VOLTS RANGE switch in 500 position, nothing connected to input posts). This indicated leakage between grid pin 2 of V104 and ground. See MAINTENANCE NOTES under "General Cleaning" for discussion of this.

7. Excessive error which appears only at low voltages when operating in the 1 volt null range - this is caused either by a defective wirewound resistor on S4 or S5 (the "D" or "E" switch), or by excessive grid current in V104. See MAINTENANCE NOTES, last paragraph on page 13, for discussion of grid current. See TROUBLE SHOOTING HINTS, heading 4A, for discussion of Kelvin-Varley non-linearity.

3. Meter needle rattle - trouble may lie in the source under measurement which is not steady or in the bucking voltage developed in the 801, or in the VTVM in the 801. To check the first two possibilities apply an absolutely steady voltage and see if meter needle wobble ceases. If it does, trouble was in the source. If wobble is still present remove signal from input posts altogether. If wobble still is present trouble is in VTVM. If wobble disappears trouble is either in 500 volt reference supply, Kelvin-Varley divider, or one of the three range dividers (if operating in other than the 500 volt range).

To track down trouble in 500V reference, use another Model 801 or 800 and monitor the output of the 500 volt reference supply of the defective 801. If 500 volts is steady, trouble is in Kelvin-Varley or range dividers. If 500 volts is not stable, trouble may lie in R17, R18, R7 or any of the tubes in this supply. Also may be a leaky feedback capacitor C6. May also be caused by trouble in the 625 volt pre-regulator.

9. Meter needle rattle with no signal applied - this occasionally occurs in the two most sensitive null ranges - .1V and .01V, and is usually caused by a microphonic 12AX7 (V100) or a defective regulator tube V103. Occasionally this rattle will appear periodic, occurring at a low frequency rate, perhaps once a second and of amplitude equal to one small meter scale division. This is often caused by a defective V103 and occasionally cured by replacement of V100.

NOTE: DO NOT APPLY GREASE OR OTHER LUBRICANTS TO SWITCH WAFERS. Some lubricants may be slightly conductive; all will collect dust and dirt. The result will be leakage which can cause considerable error particularly if the leakage occurs in the NULL switch S9. Lubricate the detent mechanism and shaft bearing if necessary, but keep the goo off the wafers ! Refer to MAINTENANCE NOTES, page 15, under GENERAL CLEANING for instructions on switch wafer cleaning and re-coating.

0. Inability to bring meter needle to zero in the .1 and .01 volt null ranges - this can be caused by overloading the chopper input filter badly - see discussion on pages 7 and 8 concerning this. If this wasn't the cause, check the mercury bias cell B1, also V100, the chopper amplifier tube. Replacement of these often clears trouble up, particularly B1. Another cause may be simple DC leakage from some higher DC (or AC) potential point on the VTVM printed circuit board to the chopper input contact or the input filter. A thorough scrubbing of this board with Metriclene M4 solvent (John B. Moore Co., Nutley, N. J.) particularly in the area of the chopper input filter, will sometimes correct trouble.

RECALIBRATION INSTRUCTIONS

If it has been positively determined that the instrument is out of calibration (see heading 4(B) on page 17), proceed as follows:

1. To calibrate basic 500 volt range apply a known 500 volts (accurate to .01% or better) to the instrument. Set 5 voltage dials to 499.910 and turn NULL dial to 1 volt position. Bring needle to zero by adjustment of the ADJ. CAL control. Then withdraw instrument part way out of the case to gain access to P2, a screwdriver adjust control located at the bottom of the large printed circuit board. Now turn VOLTS RANGE knob to CAL position and push and release the CAL PUSH button, at the same time checking for meter needle movement. With a screwdriver adjust P2 until meter needle deflection has been eliminated when the CAL PUSH button is pushed. This operation should be performed in a draft free room since a strong draft blowing across the wirewound resistors in the various dividers could cause some slight error. When meter needle movement has definitely been eliminated the instrument is in calibration. Push back in case and recheck calibration once more. If okay, apply a dab of Duco Household Cement to P2.

2. To calibrate the other three ranges, first be sure the basic 500 volt range is in calibration. Then apply a known voltage equal to the full scale value of the range being calibrated. As an example, consider the 5 volt range. Set VOLTS RANGE knob to the 5 volt position and apply a known 5 volts (accurate to .01% or better) to the instrument and turn NULL dial to the .01 volt position. Withdraw instrument part way out of case to gain access to P3, P4, and P5, the range adjustment rheostats located on the Plexiglass strip at the top front of the instrument. The left hand control adjusts the 50 volt range; the middle control adjusts the 5 volt range, and the right hand control adjusts the .5 volt range (viewed from front). With a screwdriver adjust the middle control to bring the needle to zero on the meter scale (assuming the meter needle lies on zero with nothing connected to the input posts). The 5 volt range is now in calibration.

   If it is impossible to bring the meter to zero one of the precision wirewound resistors in the 5 volt range divider has probably developed shorted turns. These resistors are R142, R143, R145 and R147. If either R142 or R143 has become defective all three of the lower ranges will be affected. R145 and R147 affect only the 5 volt range.

   A very effective independent check of the entire instrument, particularly the 5 volt range, consists of measuring the EMF of a standard cell which has been recently certified by the Bureau of your own standards group. This furnishes a known EMF of a value which will read out nicely on all 5 dials in the 5 volt range. Measure this cell with the 801 - it should read well within .03% of the certified value.

A recommended set-up for calibrating Model 800 and 801 instruments is discussed in the next section of this book.

RECOMMENDED CALIBRATION SET-UP

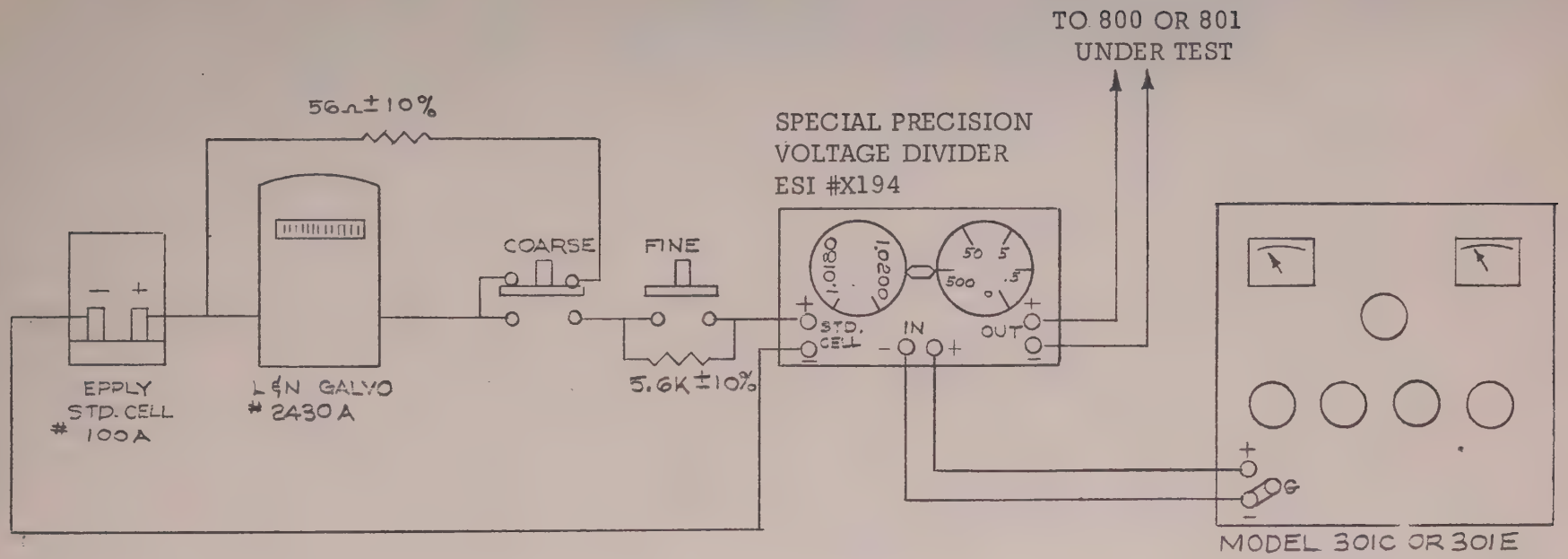
The hook-up of equipment required for final calibration of Models 800 and 801 is shown in Figure 1. The heart of this set-up is the precision voltage divider, ESI#194, built by Electro Measurements, Inc. in Portland, Oregon. This divider is so constructed that when the left hand knob is set to the exact EMF of the Eppley standard cell shown at the extreme left and the 301C output voltage controls are adjusted until the Leeds & Northrup galvo comes to null with both COARSE and FINE buttons pushed, the EMF applied to the precision divider will be 500 volts within plus or minus .005%. The precision of this divider is such that the three divided down EMF's of 50, 5, and .5 volts will also be accurate to within plus or minus .005%. These figures obtain at 72°F and the accuracy will be maintained within plus or minus .01% providing room temperature does not deviate more than plus or minus 5°F from this figure.

It is necessary, of course, that the EMF of the particular standard cell being used be known to an accuracy of plus or minus .002%. This means certification by some group who has a bank of saturated standard cells. The Eppley Model 100 standard cell is encased in a special phenolic housing which is thermally insulated and lagged. We strongly recommend that it be further insulated and lagged by housing it in an aluminum box inside of a wooden box with 3 inches of glass wool between cell and aluminum box and another 3 inches between boxes. While the Eppley 100 cell is of the unsaturated type which the Bureau of Standards will certify only to .01%, it will nevertheless maintain an extremely constant EMF if treated with care and not subjected to sudden temperature changes. Many groups will read an unsaturated cell's EMF down to the fifth place so that if you use this value in setting the standard cell knob of the ESI divider and treat the cell with care you can be reasonably sure that you are within plus or minus .002% (20 parts per million) of the true EMF of the cell. Overall accuracy of the system then is plus or minus .005% plus or minus .002% or somewhere between .003% and .007%, which is quite adequate for calibrating a .05% instrument.

JOHN FLUKE MFG. CO., INC., 1111 W. Nickerson St., Seattle 99, Wash.
Form 433-5/2/58-500

TEST EQUIPMENT SET-UP FOR

FINAL CALIBRATION OF MODELS 800 AND 801



COARSE & FINE SWITCHES ARE MOMENTARY PUSH BUTTON TYPE SHOWN IN NORMAL UNDEPRESSED POSITION. SINCE THESE SWITCHES ARE IN THE STANDARD CELL CIRCUIT THEY MUST HAVE FINE SILVER CONTACTS.

FIGURE I

MODEL 80 VOLT BOXES

Both the Model 800 and the Model 801 differential voltmeters may be used to measure voltages in excess of 500 volts by using an appropriate voltage divider or "volt box" to attenuate the EMF under measurement to 500 volts or less.

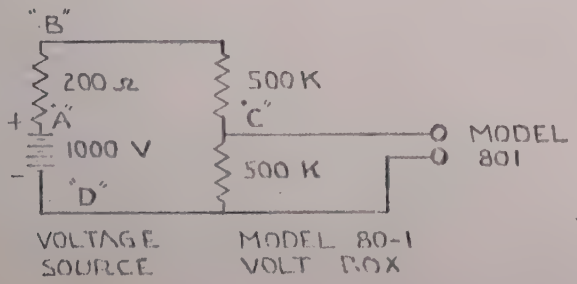
The three chief requirements of a voltage divider or "volt box" for use with the Models 800 and 801 are extreme accuracy of the division ratio, very low temperature coefficient of resistance, and excellent long term stability. The last two requirements automatically rule out all composition, deposited carbon and metal film resistors. The only type suitable is a properly aged precision wirewound unit wound with Evanohm or equivalent alloy.

The John Fluke Mfg. Co. has made available a series of volt boxes which meet the above requirements. These are the Model 80 series, and a list of the ranges available follows:

MODEL NO.	DIVISION RATIO	MAXIMUM INPUT	TOTAL RES.	CURRENT DRAWN AT MAX. INPUT	PRICE
80 - 1	2:1	1 KV	1 megohm	1 MA	$ 60
80 - 2	4:1	2 KV	2 megohms	1 MA	70
80 - 3	6:1	3 KV	3 megohms	1 MA	80
80 - 4	8:1	4 KV	4 megohms	1 MA	90
80 - 5	10:1	5 KV	5 megohms	1 MA	100
80 - 6	2:1	1 KV	10 megohms	0.1 MA	120

The division ratio of all models is accurate to .01% and long term stability is better than .01% per year. All models are housed in black phenolic boxes measuring 5-1/4" wide x 6-3/4" long x 2-1/4" deep. Output terminals are General Radio polystyrene on 3/4" centers, and the input is brought out by a pair of 6 foot flexible leads. The "hot" lead is made of a special high voltage wire insulated for better than 10 KV.

Naturally, any d-c voltage divider has resistance; the resistance of each Model 80 volt box is shown in column 4 above. The effect of this resistance is twofold. First, it affects the source under measurement since it "loads" it slightly. Second, it affects the meter used to measure the attenuated voltage since it appears to the meter as source resistance. In the case of the 800 and 801, this "source" resistance has no effect at null; it does affect the accuracy in the "search" ranges however, since the input resistance of the 800 and 801 in the 500V search position is 10 megohms. To illustrate, consider a 1,000 volt source with 200 ohms internal resistance being measured by the Model 800 used with the Model 80 - 1 volt box.



This is a simple two mesh circuit, the solution of which is shown below.

	(1) DIVIDER DISCON-NECTED	(2) DIVIDER ONLY CONNECTED	(3) DIVIDER AND 800 IN SEARCH	(4) DIVIDER AND 800 AT NULL
SOURCE EMF EAD	1000.0V	1000.0V	1000.0V	1000.0V
TERMINAL VOLTAGE EBD	1000.0V	999.80V	999.79V	999.80V
% ERROR (WRT EAD)	0%	.020%	.021%	.020%
DIVIDER OUTPUT ECD	-	499.9V	487.7V	499.9V
% ERROR (WRT EAD)	-	.02%	2.46%	.02%

CONCLUSION: The volt box has a definite loading effect on the source under measurement. If the internal resistance of the source is known, the loading error can be computed and final readings corrected accordingly. In the case above this loading error is .02%.

The Model 800 at null presents an infinite impedance to the source under measurement, in this case the divided down voltage. Therefore, there is no additional error caused by voltmeter loading. This is clearly indicated by comparing the values under headings (2) and (4) - the output of the divider with the 800 or 801 connected and brought to a null is exactly the same as the calculated output with nothing connected to the divider.

JOHN FLUKE MFG. CO., INC., 1111 W. Nickerson St., Seattle 99, Washington
Form 311B - 5/2/58 - 200

ADDENDUM

This instrument may utilize Amperex 7316 vacuum tube in place of 12AU7 for V104 only. Both tubes are directly interchangeable without circuit modification. Do not use the 7316 for V4.

MODEL 801

LIST OF REPLACEABLE PARTS

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
C1,C2	Capacitor, oil 1 mfd, 1000 v	CO20
C3	Capacitor, paper .1 mfd, 600 v	CP5
C5,C103 thru C107	Capacitor, paper .047 mfd, 400 v	CP6
C6	Capacitor, paper .01 mfd, 1600 v	CP1
C7	Capacitor, mylar .1 mfd, 600 v	CP20
C100	Capacitor, paper .01 mfd, 600 v	CP7
C101	Capacitor, electrolytic 2 section 10/10 mfd, 450 v	CE13
C102	Capacitor, mylar .022 mfd, 600 v	CP18
C109,C110	Capacitor, mylar .22 mfd, 400 v	CP19
C111	Capacitor, polystyrene 1 mfd, 200 v	CO22
C112	Capacitor, ceramic 220 mmfd, 500 v	CT1
R1	Resistor, composition 390Ω, ±10%, 1 w	GB3911
R2	Resistor, composition 470 k, ±10%, 1/2 w	EB4741

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R3A thru F R4A,B	Resistor, composition 22 k, ±10%, 1 w	GB2231
R5	Resistor, deposited carbon 500 k, ±1%, 2 w	DR620
R6	Resistor, deposited carbon 144 k, ±1%, 1 w	DR67
R7	Resistor, precision wirewound 149 k, ±.5%, 1 w	PR611
R8,12,14,111 112,116,117,120	Resistor, composition 1 m, ±10%, 1/2 w	EB1051
R9,10	Resistor, deposited carbon 300 k, ±1%, 1 w	DR614
R13	Resistor, deposited carbon 250 k, ±1%, 1 w	DR613
R15,19	Resistor, precision wirewound 125 k, ±.1%, 1 w	PR610
R16	Resistor, precision wirewound 509Ω, ±.1%, 1/2 w	PR37
R17	Resistor, precision wirewound 320 k, ±.5%, 1 w	PR614
R18	Resistor, precision wirewound 158 k, ±.1%, 1 w	PR620
*R20 thru 25	Resistor, precision wirewound 40 k, ±.02%, 1/2 w, matched	PR512
*R26 thru 36	Resistor, precision wirewound 8 k, ±.05%, 1/2 w, matched	PR48
*R37 thru 47	Resistor, precision wirewound 1.6 k, ±.1%, 1/2 w, matched	PR46
*R48 thru 58	Resistor, precision wirewound 320Ω, ±.1%, 1/2 w, matched	PR39
*R59 thru 68	Resistor, precision wirewound 64Ω, ±.1%, 1/2 w, matched	PR24

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R69,114,115	Resistor, composition 39 k, ±10%, 1 w	GB3931
R101	Resistor, composition 56Ω, ±10%, 1 w	GB5601
R102A,B	Resistor, composition 2.7 k, ±10%, 1 w	GB2721
R104A,B R106A,B,108	Resistor, composition 4.7 k, ±10%, 1 w	GB4721
R109,110	Resistor, deposited carbon 8.2 k, ±1%, 1/2 w	DR411
R113	Resistor, composition 10 k, ±10%, 1 w	GB1031
R118,125	Resistor, composition 2.2 m, ±10%, 1/2 w	EB2251
R119	Resistor, deposited carbon 2.2 m, ±1%, 1/2 w	DR73
R121	Resistor, composition 10 m, ±10%, 1/2 w	EB1061
R122	Resistor, deposited carbon 5 k, ±1%, 1/2 w	DR49
R123,124	Resistor, composition 220 k, ±10%, 1/2 w	EB2241
R126	Resistor, deposited carbon 4.4 m, ±1%, 1/2 w	DR74
R127,128	Resistor, deposited carbon 4.5 m, ±1%, 1/2 w	DR75
R129	Resistor, deposited carbon 500 k, ±1%, 1/2 w	DR618
R130,134,137	Resistor, deposited carbon 900 k, ±1%, 1/2 w	DR622
R131	Resistor, deposited carbon 103.5 k, ±1%, 1/2 w	DR63
R132	Resistor, deposited carbon 4.99 m, ±1%, 1/2 w	DR76

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R133,136	Resistor, deposited carbon 9 m, ±1%, 1 w	DR78
R135,138	Resistor, deposited carbon 90 k, ±1%, 1/2 w	DR513
R139	Resistor, deposited carbon 10 k, ±1%, 1/2 w	DR51
R140	Resistor, composition 270Ω, ±10%, 1 w	GB2711
R141	Resistor, composition 27 k, ±10%, 1 w	GB2731
R142,143	Resistor, precision wirewound 112,375Ω, ±.05%, 1 w	PR615
R144	Resistor, precision wirewound 28,571Ω, ±.05%, 1/2 w	PR515
R145	Resistor, precision wirewound 2531.7Ω, ±.05%, 1/2 w	PR49
R146	Resistor, precision wirewound 250.31Ω, ±.05%, 1/2 w	PR311
R147	Resistor, precision wirewound 22.5 k, ±.1%, 1/2 w	PR513
R148	Resistor, precision wirewound 24.75 k, ±.1%, 1/2 w	PR514
P1	Potentiometer, wirewound 1 k, ±10%, 2 w	P1KA
P101,104	Potentiometer, wirewound 5 k, ±10%, 2 w	P5KA
P3,4,5	Rheostat, wirewound 600Ω, ±20%, 2 w	P600A
P2	Rheostat, wirewound 5Ω, ±20%, 2 w	P5A
P6	Potentiometer, wirewound, (Trimit) 5 k, ±20%, 1/4 w	P5000TA

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
P102,103	Potentiometer, wirewound 10 k, ±10%, 2 w	P10KA
V1	Tube, high vacuum recitifier Type 5Y3-GT	5Y3-GT
V2	Tube, pentode Type 6AQ5	6AQ5
V3	Tube, pentode Type 6AU6	6AU6
V4,104	Tube, dual triode Type 12AU7	12AU7
V5,102	Tube, voltage regulator Type OA2	OA2
V6,100	Tube, dual triode Type 12AX7	12AX7
V7,8	Tube, voltage reference Type OG3	OG3
V101	Tube, current regulator Type 9-7	9-7
V103	Tube, voltage regulator Type OB2	OB2
C105	Tube, triode Type 6C4	6C4
RE1,2,3	Rectifier, selenium 117 v, 65 ma	RE1A
S1	Switch, rotary 2 pole, 5 position, shorting	SR18
S2,3,4	Switch, rotary 2 pole, 10 position, shorting	SR19
S5	Switch, rotary 1 pole, 11 position, shorting	SR20

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
S6	Switch, toggle SPST 3A/250 v	ST5
S7	Switch, push button Momentary on	SP1A
S8	Switch, rotary 8 pole, 5 position	SR28
S9	Switch, rotary 6 pole, 5 position	SR29
B1	Mercury cell 1.35 v bias type	X44
B2	Standard cell, non-saturated, low hysteresis	X223
CK1	Chopper, SPDT, BBM 6.3 v, 60 c coil	X100
F1	Fuse - cartridge 2 amperes	F2
M1	Meter, 50-0-50 microamp. with special scale	M12B
PL1 thru 4	Lamp - 6.3 v - .25 ampere Min. bayonet base	X34
T1	Transformer, power	T9
	Fuse holder Bayonet type	X12
	Binding post	X219
	Binding post insulator, black	X218
	Binding post insulator, red	X217
	Binding post spacer	X220
	Binding post shorting link	X221

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
	Knob, 2 inch, no pointer	X233
	Knob, 1 inch, pointer	X231
	Cable, power, 2 conductor #18	X27E
	Bushing, line cord strain relief	X212
	Feet, rubber mounting	X224
	Handle, leather	X241
	Studs, handle mounting	X248
	Shaft, handle mounting	407-201-0
	Washer, flat insulated for potentiometer mounting	X93
	Washer, shoulder insulated for potentiometer mounting	X93A

* These 49 resistors are factory matched for each instrument. When ordering, specify instrument serial number for each resistor ordered. See page 9, paragraph 4 of the manual for additional information.

WARRANTY

he JOHN FLUKE MFG. CO., INC. warrants each instrument manufactured by them to be ee from defects in material and workmanship. Their obligation under this Warranty is mited to servicing or adjusting an instrument returned to their factory for that purpose, nd to making good at their factory any part or parts thereof; except tubes, fuses, chop-ers and batteries, which shall, within one year after making delivery to the original urchaser, be returned by the original purchaser to them with transportation charges repaid, and which on their examination shall disclose to their satisfaction to have been hus defective. If the fault has been caused by misuse or abnormal conditions of opera-ion repairs will be billed at cost. In this case, an estimate will be submitted before vork is started, if requested.

f any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information we will give you service data or shipping instructions.

2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

All shipments of JOHN FLUKE MFG. CO., INC. instruments should be made via Railway Express prepaid. The instrument should be shipped in original packing carton, or if not available any suitable container that is rigid. If substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

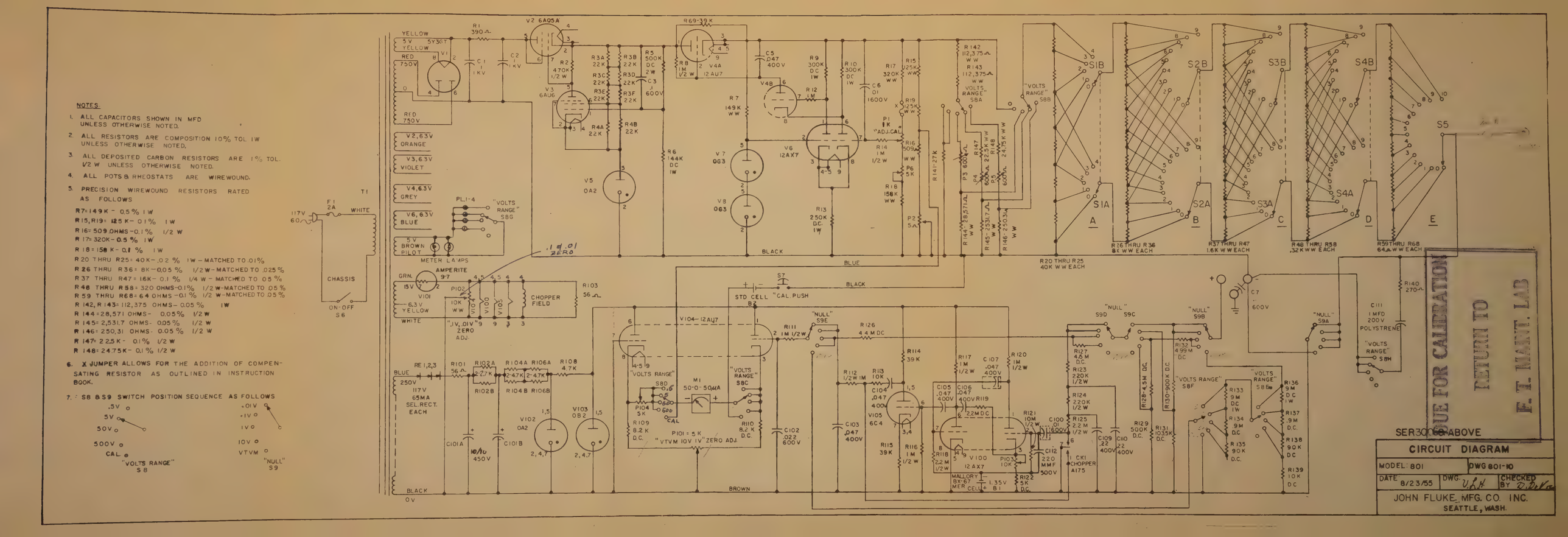
CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt of same. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include Model number, type number, and serial number when referring to this instrument for any reason.

Do not hesitate to contact us concerning any questions which you may have about this instrument. The JOHN FLUKE MFG. CO., INC. will be happy to answer all application questions which will enhance your use of this instrument.

JOHN FLUKE MFG. CO., INC., 1111 WEST NICKERSON STREET, SEATTLE 99, WASH.

Form 314-200-1/30/58


NOTES
1. ALL CAPACITORS SHOWN IN MFD UNLESS OTHERWISE NOTED.
2. ALL RESISTORS ARE COMPOSITION 10% TOL 1W UNLESS OTHERWISE NOTED.
3. ALL DEPOSITED CARBON RESISTORS ARE 1% TOL. 1/2 W UNLESS OTHERWISE NOTED.
4. ALL POTS & RHEOSTATS ARE WIREWOUND.
5. PRECISION WIREWOUND RESISTORS RATED AS FOLLOWS
R7=149K - 0.5% 1W
R15,R19= 125K - 0.1% 1W
R16= 509 OHMS -0.1% 1/2 W
R17= 320K - 0.5 % 1W
R18 = 158 K - 0.1 % 1W
R20 THRU R25= 40K - .02 % 1W - MATCHED TO .01%
R26 THRU R36= 8K - 0.05 % 1/2W - MATCHED TO .025%
R37 THRU R47= 16K - 0.1 % 1/4 W - MATCHED TO 0.5 %
R48 THRU R58= 320 OHMS-0.1% 1/2 W-MATCHED TO 0.5 %
R59 THRU R68= 64 OHMS -0.1 % 1/2 W-MATCHED TO 0.5 %
R 142, R 143= 112,375 OHMS - 0.05 % 1W
R 144 = 28,571 OHMS - 0.05% 1/2 W
R 145 = 2,531.7 OHMS - 0.05 % 1/2 W
R 146 = 250.31 OHMS - 0.05 % 1/2 W
R 147 = 22.5 K - 0.1% 1/2 W
R 148 = 24.75 K - 0.1 % 1/2 W
6. X JUMPER ALLOWS FOR THE ADDITION OF COMPENSATING RESISTOR AS OUTLINED IN INSTRUCTION BOOK.
7. S8 & S9 SWITCH POSITION SEQUENCE AS FOLLOWS
.5V
5V
50V
500V
CAL
"VOLTS RANGE" S8
.01V
.1V
1V
10V
VTVM
"NULL" S9
T1
F1 2A
117V 60
WHITE
CHASSIS
ON-OFF S6
V2 6AQ5A
V3 6AU6
V4A 12AU7
V4B
V5 0A2
V6 12AX7
V7 0G3
V8 0G3
R1 390Ω
C1 .1 1KV
C2 .1 1KV
R2 470K 1/2W
R3A 22K
R3B 22K
R3C 22K
R3D 22K
R3E 22K
R3F 22K
R4A 22K
R4B 22K
R5 500K DC 2W
C3 J 600V
R6 144K DC 1W
R7 149K WW
R8 1M 1/2 W
R9 300K DC 1W
R10 300K DC 1W
R12 1W
R13 250K DC. 1W
R14 1M 1/2 W
R15 125K WW
R16 509 WW
R17 320K WW
R18 158K WW
R69-32K
C5 .047 400V
C6 .01 1600V
P1 1K "ADJ.CAL"
P2 5K
P3 600Ω
P4 600Ω
P5 600Ω
P6 5K
R141-27K
R142 112,375Ω WW
R143 112,375Ω WW "VOLTS RANGE" S8A
R144 28571Ω WW
R145 2531.7Ω WW
R146 250.34Ω WW
R147 22.5K WW
R148 24.75K WW
"VOLTS RANGE" S8B
S1A S1B S2A S2B S3A S3B S4A S4B S5
A B C D E
R20 THRU R25 40K WW EACH
R26 THRU R36 8K WW EACH
R37 THRU R47 1.6K WW EACH
R48 THRU R58 .32K WW EACH
R59 THRU R68 64Ω WW EACH
PL1-4 METER LAMPS
"VOLTS RANGE" S8G
.1 .01 ZERO
AMPERITE 9-7
V101 6.3V YELLOW
V102 V103 V104 V105
10K WW "1V, .01V ZERO ADJ"
CHOPPER FIELD
R103 56
S7 STD CELL "CAL PUSH"
V104-12AU7
R111 2 1M 1/2W
R126 4.4 M DC
"NULL" S9E
"NULL" S9D
"NULL" S9C
"NULL" S9B
"NULL" S9A
RE1,2,3 250V 117V 65MA SEL. RECT. EACH
R101 56
R102A 2.7K
R102B
R104A R106A 2.47K 2.47K
R104B R106B
R108 4.7K
C101A C101B 10/10 450V
V102 0A2
V103 0B2
M1 50-0-50μA
P101 = 5K "VTVM 1V 1V" ZERO ADJ
"VOLTS RANGE" S8C
R109 8.2K D.C.
R110 8.2K D.C.
P104 5K
S8D .5 5 50 500 CAL
C102 .022 600V
R112 1/2W 1M
R113 10K
C104 .047 400V
V105 6C4
R114 39K
R115 39K
R116 1M 1/2 W
C103 .047 400V
R117 1M 1/2W
C107 .047 400V
R120 1M 1/2W
C105 .047 400V
C106 .047 400V
R119 .22M DC
V106 12AX7
R118 2.2M 1/2W
R121 10M 1/2W
C100 .01 1600V
C112 220 MMF 500V
P103 10K
R122 5K D.C.
MALLORY RX-67 MER. CELL 1.35V B1
1 CK1 CHOPPER A175
R123 220K 1/2W
R124 220K 1/2W
R125 2.2 M 1/2 W
C109 .22 400V
C110 .22 400V
R127 4.5M D.C.
R128 4.5M D.C.
R129 500K D.C.
R130 900K D.C.
R131 105K D.C.
R132 4.99M D.C.
"VOLTS RANGE" S8F
"VOLTS RANGE" S8E
R133 9M DC 1W
R134 9M DC
R135 90K D.C.
R136 9M D.C. 1W
R137 .9M D.C.
R138 90K DC
R139 10K DC
C7 .1 600V
C111 1 MFD 200V POLYSTYRENE
"VOLTS RANGE" S8H
R140 270
R140 270
BLUE
BLACK
BROWN
0V
SER 3000 & ABOVE
CIRCUIT DIAGRAM
MODEL: 801
DWG 801-10
DATE 8/23/55
DWG. V.L.H
CHECKED BY D.D.L.
JOHN FLUKE MFG. CO. INC.
SEATTLE, WASH.
RETURN TO
E. T. MAINT. LAB
ISSUE FOR CALIBRATION

C-59 CATALOG

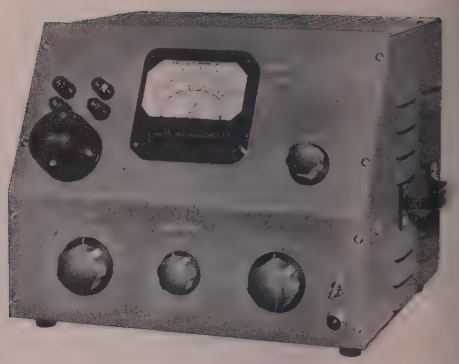
- VAW METER
- POWER SUPPLIES
  - Precision calibrated
  - Nuclear — High Voltage
  - High resolution
  - High stability
- PRECISION DC POTENTIOMETRIC VOLTMETERS
- PRECISION DC-AC DIFFERENTIAL VOLTMETER

john fluke MANUFACTURING COMPANY, INC.
1111 W. NICKERSON STREET • SEATTLE 99, WASHINGTON

VAW METER

MODEL 102

For Measuring Volts—Amperes—Watts



FEATURES

- 20 CPS to 20 KC
- 10% and Unity Power Factor Ranges
- 1.5 to 600 Volts AC
- .0015 to 30 Amperes
- Negligible Circuit Burden
- True Electrodynamometer Action

The Model 102 VAW METER is an electronic instrument for the measurement of voltage (V), current (A) and power (W) over a wide range of frequency, voltage, current and power factor. Voltage, current and power readings are made directly on a linear meter scale. Owing to its high sensitivity, the VAW METER is characterized by its ability to read power from microwatts to kilowatts. Its high input impedance and low shunt drop produce negligible insertion effects on the circuit under test. Power readings are inherently without waveform error for all frequency components within specified frequency range. The VAW METER is ideally suited to measuring true power consumed by a wide variety of loads including both linear and non-linear elements such as servo components, transformers, rectifiers and substantially any power consuming circuit configuration. Additionally, it will be found exceptionally useful in measuring amplifier output power into the actual amplifier load, obsoleting the substitution method of utilizing resistance loading for estimating amplifier's power output.

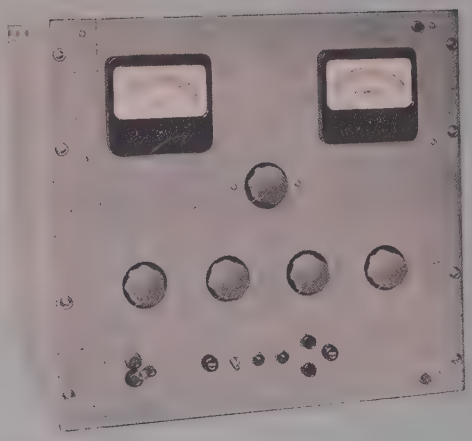
SPECIFICATIONS

Frequency Range:	20 CPS to 20 KC.
Voltage Ranges:	1.5, 3, 6, 15, 30, 60, 150, 300, 600 volts RMS full scale; selected by voltage range switch on front panel.
Current Ranges:	.0015, .003, .006, .015, .03, .06, .15, .3, .6, 1.5, 3, 6, 15, 30 RMS amperes full scale; selected by plugging in shunts on the front panel.
Power Ranges:	Wattmeter readings are direct readings in watts taking into account the "Power Factor" switch setting of either .1 or 1. With the "Power Factor" switch set at 1 the wattmeter reads VA cos o; with this switch set at .1 the wattmeter reads .1 VA cos o. Thus the full-scale watts range from 225 microwatts to 18 kilowatts, or the product of any full-scale current, any full-scale voltage and either .1 or 1.
Shunt Drop:	45 millivolts at full-scale current.
Input Resistance:	1 megohm for all voltage ranges.
Accuracy:	Better than 3% of full scale within the rated frequency range.
Meter Scales:	Voltage, current and power are read on the same meter arcs by selection of the desired quantity by positioning the "VAW" switch.
Input Voltage:	105 to 130 volts 50/60 CPS only.
Accessories:	The Model 102 VAW Meter is supplied with one shunt of any value listed above under "Current Ranges" as selected by the purchaser. Additional shunts may be purchased as extra equipment.
Mounting:	Smooth grey baked enamel on front panel, machine engraved. Grey wrinkle on case exterior. Over-all dimensions are 13" W x 10" H x 12" D, exclusive of handles and knobs.
Net Weight:	35 pounds.
Shipping Weight:	52 pounds.
Price:	$555.00 F.O.B. Factory, Seattle, Washington, with one shunt of listed rating. Additional shunts are $20.00 each F.O.B. Factory.

PRECISION POWER SUPPLY

MODEL 301C

1.02 — 1012 VDC



FEATURES

- 1.02 to 1012 VDC — 0 to 400 MA
- .005% Regulation
- Chopper Stabilized
- Standard Cell Reference
- 500 Microvolt Resolution
- .1% Calibration Accuracy

The Model 301C is a chopper stabilized, standard cell referenced, calibrated precision DC power supply which will satisfy the most exacting requirements of laboratory or production line.
With its 400 milliampere, 1 KV output, it is truly a brute force supply. Because of extremely conservative transformer design it may be operated at full load indefinitely with no ill effects.
Five decade voltage controls afford resolution of .5 millivolt over the entire operating range, and absolute accuracy is better than .1%. Use of a standard cell reference and chopper stabilization imparts to the 301C output voltage stability of better than .01% long term

A unique hinged panel affords instant access to the printed circuitry without removing the instrument from its rack. This construction also isolates the standard cell and precision wirewound sampling strings for all heat generating elements. A compact, rugged unit of incomparable performance, the 301C stands alone in its field.

SPECIFICATIONS

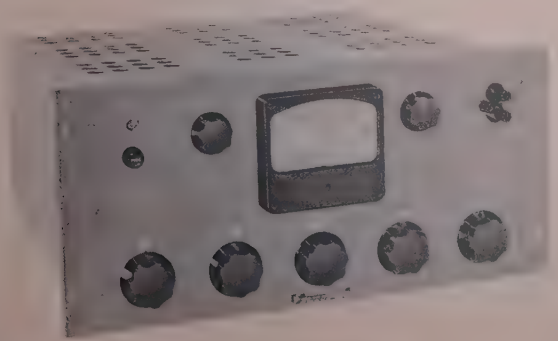
Input Voltage:	117 volts, 50/60 cycles. Can be supplied for 234 volts 50/60 cycles
Input Power:	875 watts fully loaded, 190 watts standby
Output Voltage:	1.02 to 1012 volts DC
Output Current:	0 to 400 milliamperes
Output Polarity:	Either side may be grounded, or both sides may be left floating
Output Connector:	Gen. Rad. binding posts on ¾" centers
Regulation vs. line:	.005% or 1 millivolt for 10% line voltage change
Regulation vs. load:	.005% or 1 millivolt for 200 milliampere load current change
Stability:	.005% per hour after short warm-up, less than .01% per day
Reference element:	Low hysteresis standard cell
Equating element:	Type A-12 low noise chopper
Ripple:	Less than 2 millivolts RMS
Voltage Calibration:	9 —100 volt steps 10— 10 volt steps 10— 1 volt steps 10— .1 volt steps 1 — .11 volt vernier
Voltage Resolution:	.5 millivolt at any output voltage via .11 volt Vernier
Voltage Resettability:	.01%
Calibration Accuracy:	± .1% or 2 millivolts
Meters:	4" Voltmeter 0-1000 volts 4" Milliammeter 0-500 milliamps
Size:	19" W x 17½" H x 15" D. Panel slotted to RMA standards. Equipped with hardwood skids for bench use
Net Weight:	120 pounds
Shipping Weight:	133 pounds
Price:	$985.00 F.O.B. Factory, Seattle, Washington

PRECISION POWER SUPPLY

MODEL 301E

1.02 — 512 VDC

The Model 301E, like the Model 301C, is a chopper stabilized, ultra stable, calibrated power supply. The specifications for the Model 301E are identical to those of the 301C, with the following exceptions:



SPECIFICATIONS

Input Voltage:	117/234 volts, 50/60 cycles, single phase
Input Power:	350 watts fully loaded, 110 watts standby
Output Voltage:	1.02 volts to 512 volts DC
Output Current:	0 to 300 milliamperes
Regulation vs. Load:	.005% or 1 millivolt for 150 milliampere load current change
Voltage Calibration:	4—100 volt steps 10— 10 volt steps 10— 1 volt steps 1— .11 volt vernier
Size:	19" W x 8¾" H x 18" D Panel slotted to RMA standards. Equipped with resilient feet for bench use.
Net Weight:	37 pounds
Shipping Weight:	53 pounds
Price:	$595.00 F.O.B. Factory, Seattle, Washington

HIGH RESOLUTION DC POWER SUPPLY

MODEL 406

FEATURES

- 0 to 530 Volts DC
- 0 to 100 Milliamperes
- .01% Line and Load Regulation
- 2 Millivolt Resolution
- .01% Short Term Stability
- 1 Millivolt Maximum Ripple
- Dual Range Bias and 6.3 V AC 3 Amp. Outputs

HIGH STABILITY, HIGH RESOLUTION SUPPLY FOR INSTRUMENT CALIBRATION WORK

The Model 406 incorporates features which make it an ideal laboratory or general purpose power supply. Use of differential type equating circuits and precision wire-wound sampling circuits impart to the Model 406 a degree of stability seldom encountered outside the most expensive laboratory supplies. Coarse, fine and vernier output voltage controls permit setting the output of the Model 406 to within 2 mv. of any value desired over its entire range. A high voltage "OFF" position is provided on the meter circuit switch for disconnecting the high voltage from main output posts without affecting other outputs.

The Model 406, when used with the John Fluke Model 800 Differential Voltmeter, provides the most convenient and economical DC calibrating team available. Light weight, compact, and highly portable, the Model 406 is an ideal laboratory power supply, a rugged production line unit, and an excellent stable voltage source for DC instrument calibration work.

SPECIFICATIONS

Input Voltage:	117 volts, 50/60 cycles. Can be supplied for 234 volts, 50/60 cycles.
Output Voltage:	0 to 530 volts dc
Output Current:	0 to 100 milliamperes
Regulation:	.01% or 50 millivolts for line voltage variation from 105 to 130 volts .01% or 50 millivolts for load current changes from 0 to 100 milliamperes
Stability:	.01% or 50 millivolts per hour .05% or 250 millivolts per day
Ripple:	1 millivolt or less
Voltage Resolution:	2 millivolts over entire range via vernier control

MODEL 406R

Output Polarity:	Either positive or negative side of output may be grounded, or both sides may be left floating. Two supplies may be series connected with either side of either supply grounded.
Auxiliary Outputs:	(DC) 0 to —225 volts and 0 to —22.5 volts bias supply. Positive side connected to negative side of main output. Line regulation .02%. 1 mv max. ripple. Output impedance 0 to 10,000 ohms depending on setting of bias control. (AC) 6.3 volts at 3 amperes unregulated; winding insulated for 1000 volts rms. to ground.
Size:	Cabinet Model: 9¾" W x 13" H x 14" D Rack Model: 19" W x 8¾" H x 16¾" D
Net Weight:	Cabinet Model: 28 pounds Rack Model: 35 pounds
Shipping Weight:	Cabinet Model: 35 pounds Rack Model: 44 pounds
Price:	Cabinet Model: $285.00 F.O.B. Factory, Seattle, Washington Rack Model: $285.00 F.O.B. Factory, Seattle, Washington

Where applications require deleting all output terminals from front panel, the Model 406A (Cabinet Model) is available at $320.00 F.O.B. Factory, Seattle, Washington. All outputs plus the AC input are brought out through an AN 3102-28-9P connector located on the rear of the case.

HIGH RESOLUTION DC POWER SUPPLY

MODEL 407

FEATURES

- 0 to 555 VDC — 0 to 300 MA
- .01% Regulation
- .05% Long Term Stability
- Dual Bias and Filament Outputs
- 2 Millivolt Resolution
- Excellent for Instrument Calibration

The Model 407 is unquestionably the finest DC supply of its type available today. Through the use of silicon rectifiers, printed circuitry and light-weight aluminum construction, the size and weight of this unit have been kept to the absolute minimum consistent with the high order of performance and reliability associated with the John Fluke name.

The extreme stability of this supply is due in large part to the use of highest quality precision wirewound resistors in sampling circuits, and at all critical points. All potentiometers are likewise wirewound and the reference tube is an aged unit operated at constant current. Accordingly, the voltage controls are calibrated and may be used for the direct calibration of multimeters and panel instruments. A high voltage "OFF" position is provided on the meter circuit switch for disconnecting the high voltage from main output posts without affecting other outputs.

The high order of regulation against both line voltage and load current changes results from the use of balanced equating circuits, heater voltage stabilization and pentode series passing and amplifier tubes.

SPECIFICATIONS

Input Voltage:	117/234 volts, 50/60 cycles
Input Power:	425 watts fully loaded, 100 watts standby
Main Output Voltage:	0 to 555 volts DC
Main Output Current:	0 to 300 milliamperes
Regulation:	.01% or 50 millivolts for line voltage variation from 105 to 130 volts. .01% or 50 millivolts for load current change from 0 to 300 milliamperes
Output Impedance:	Less than .5 ohm DC to 100 KC at max. output
Stability:	.01% or 50 millivolts per hour .05% or 250 millivolts per day
Ripple:	1 millivolt RMS or less
Voltage Resolution:	2 millivolts over entire range via 0 to .55V control
Voltage Controls:	0 to 500 volts, ten 50 volt steps 0 to 55 volts, smoothly variable 0 to .55 volts, smoothly variable
Calibration Accuracy:	Better than .5% from 50 to 500 volts when set up by the 0-500 volt control.
Output Polarity:	Either positive or negative side of main output may be grounded, or both sides may be left floating. Two supplies may be series connected with either side of either supply grounded.
Meter:	Illuminated 4½-inch square meter with MTR. CKT. switch for selectively reading HV output voltage, BIAS output voltage and HV output current. Switch also disconnects HV output from output binding posts when turned to extreme CCW position.
Meter Ranges:	0 to 300 milliamperes 0 to 600 volts with MTR. RANGE switch in 600 V position. 0 to 60 volts with MTR. RANGE switch in 60 V position.
Auxiliary Outputs:	(DC) 0 to —250 volts and 0 to —25 volts bias supply, variable via BIAS control. Max. current output 5 milliamperes at 250 volts. Positive side connected to negative side of main output. Line regulation .02%. 1 millivolt max. ripple. Output impedance 0 to 10,000 ohms depending on setting of bias control. At 250 volt setting load regulation .01% for 5 milliampere load change. (AC) Two independent 6.3 volt 5 amp. outputs. Each winding insulated for 1500 volts RMS to ground. Phasing indicated at binding posts for series or parallel connections.
Output Connectors:	All outputs brought out to binding posts on ¾" centers. Also brought out to terminal strip at rear on rack mounting model.
Size:	Cabinet Model: 9¾" W x 13" H x 14" D Rack Model: 19" W x 8¾" H x 16¾" D
Net Weight:	Cabinet Model: 34 pounds Rack Model: 36 pounds
Shipping Weight:	Cabinet Model: 42 pounds Rack Model: 50 pounds
Price:	Cabinet Model: $335.00 F.O.B. Factory, Seattle, Washington Rack Model: $335.00 F.O.B. Factory, Seattle, Washington

Where applications require deleting all output terminals from front panel, the Model 407A (Cabinet Model) is available at $377.00 F.O.B. Factory, Seattle, Washington. All outputs plus the AC input are brought out through an AN 3102-28-9P connector located on the rear of the case.

MODEL 407R

HIGH VOLTAGE

High Resolution Nuclear Power Supply

MODEL 402M

500 — 1600 VDC

The Model 402M is a stable, well regulated source of DC voltage in the range of 500 to 1600 volts. The close regulation, high order of stability, and freedom from corona, output jitter and bounce make it an excellent voltage source for counters, multiplier photocells and other devices used in nuclear work. The Model 402M employs a high gain regulator system wherein a portion of the output voltage is compared with a reference voltage and the error amplified and applied to a series passing tube to effect correction. The sample portion is selected by a precision resistor string while a stabilized twin triode tube operated as a differential amplifier serves as the comparison element. Feedback systems are employed to reduce ripple and output impedance to a minimum.

Highest quality components and workmanship are employed throughout, ensuring long, trouble-free operation. The power transformer is of very conservative design, manufactured by this concern, and carries an unconditional lifetime guarantee against defects in material and workmanship.

SPECIFICATIONS

Input Voltage:	117 volts, 50/60 cycles, single phase Can be supplied for 234 volts, 50/60 cycles
Input Power:	20 watts fully loaded
Output Voltage:	500 to 1600 volts
Output Current:	0 to 1 milliampere
Output Polarity:	Positive or negative with respect to chassis, selected by front panel switch.
Regulation vs. Line:	.03% maximum for line change from 105 to 130 volts
Regulation vs. Load:	.03% no load to full load
Stability:	.01% per hour, .1% per day
Ripple:	Less than 5 mv RMS at any output voltage and current in either polarity mode
Voltage Calibration:	10-100 volt steps 1-100 volt vernier
Voltage Resolution:	100 mv at any output voltage
Calibration Accuracy:	Better than .5% by X100 control
Meters:	0-2kv 4" square. Better than 3% accuracy
Connectors:	See Page 15
Size:	19" W x 7" H x 13" D. Slotted to RMA standards. Equipped with resilient feet for bench use.
Net Weight:	22 pounds
Shipping Weight:	37 pounds
Finish:	Smooth grey, high-gloss, baked enamel, machine engraved.
Price:	$280.00 F.O.B. Factory, Seattle, Washington

Special models of the 402M are available with fixed voltage, fixed polarity and without meters. Please contact the factory for your special requirements.

HIGH VOLTAGE

High Resolution Nuclear Power Supply

MODEL 403M

The Model 403M is identical to the Model 402M, with the following exceptions:

Stability:	.02% per hour, .1% per day after warm-up.
Calibration Accuracy:	Better than 1% by X100 control.
Price:	$220.00 F.O.B. Factory, Seattle, Washington

Special models are available with fixed voltage, fixed polarity, and without meters. Please contact the factory for your special requirements.

HIGH VOLTAGE

High Resolution Nuclear Power Supply

500 TO 2000 VOLTS

MODEL 404M

FEATURES

- 500 to 2000 Volts Output
- 0 to 5 Milliamperes
- Selective Output Polarity
- Output Free from Jitter
- Zero Voltage Overshoot

The Model 404M is an extremely stable, highly regulated DC source covering the range of 500 to 2000 volts at 5 milliamperes.
Instantaneous output polarity reversal is accomplished by a switch on the front panel. Regulated output voltage is available by a connector on the rear skirt, in addition to the one on the front panel. A 1.02 volt sample of the output is available at a pair of binding posts on the front panel.
An anti-overshoot circuit is incorporated in the supply to prevent the output voltage from overshooting the pre-set level during warm up.

SPECIFICATIONS

Input Voltage:	117 volts, 50/60 cycles, single phase. Can be supplied for 234 volts, 50/60 cycles
Input Power:	45 watts fully loaded
Output Voltage:	500 to 2000 volts
Output Current:	0 to 5 ma, at 500-1500 V 0 to 2 ma, at 500-2000 V
Output Polarity:	Positive or negative with respect to chassis, selected by front panel switch
Output Connector:	See Page 15
Regulation vs. Line:	Better than .01% for line voltage change from 100 to 130 volts
Regulation vs. Line:	.01% maximum for 2 ma change
Stability:	Better than .005% per hour, .05% per day after warm up
Ripple:	Less than 5 mv RMS at any output voltage and current in either polarity
Voltage Calibration:	14-100 volt steps 1-100 volt vernier
Calibration Accuracy:	Better than .5% by X100 control
Voltage Resolution:	100 millivolts at any output setting
Voltage Overshoot:	None, under any conditions
Voltage Resettability:	Better than .1%
Meter:	0-2KV 4" square, 2% accuracy
Net Weight:	28 pounds
Shipping Weight:	42 pounds
Size:	19" W x 7" H x 13" D. Slotted to RMA Standards. Equipped with resilient feet for bench use.
Finish:	Smooth grey baked enamel, machine engraved
Price:	$435.00 F.O.B. Factory, Seattle, Washington

Special models are available upon request. Contact the factory for special requirements.

HIGH VOLTAGE

NUCLEAR POWER SUPPLY

MODEL 409

170 — 1530 VDC

FEATURES

- 170 to 1530 Volts Output
- 0 to 5 Milliamperes
- Selective Polarity
- .02% Stability

The Model 409 is an extremely stable DC source covering the range of 170 to 1530 volts. The five milliampere output current capability permits simultaneous operation of several multiplier tubes. Circuit employs hermetically-sealed silicon rectifiers, power transformer and filter capacitors. Only highest quality Steatite and Mycalex switches are used.

SPECIFICATIONS

Input Voltage:	117 volts, 60 cycles, single phase
Output Voltage:	170 to 1530 volts DC
Output Current:	0 to 5 milliamperes over entire voltage range
Output Polarity:	Positive or negative—selective
Stability:	.02%
Output Connector:	See page 15
Ripple:	Less than .002% at any output voltage or current in either polarity
Regulation vs. line:	.01% max. for 10 volt line change
Regulation vs. load:	.4% max. for 1 milliampere load change
Stability:	.02% per day, after warm-up
Size:	19" W x 3½" H x 12" D. Equipped with removable resilient feet for bench use
Net Weight:	22 pounds
Shipping Weight:	34 pounds
Price:	$335.00 F.O.B. Factory, Seattle, Washington

HIGH VOLTAGE

High Stability Nuclear Power Supply

MODEL 405

600-3100 VDC

FEATURES

- 600-3100 VDC—0 to 15 MA
- .005% Load Regulation
- Selective Output Polarity
- .005% Stability
- 10 Millivolt Resolution
- Excellent Long-term Stability

The Model 405 is a highly stable, calibrated, high voltage power supply free from bounce, jitter and corona. Residual ripple is less than 5 millivolts under all conditions. This model employs precision wirewound sampling circuits, differential amplifiers and a tetrode series passing tube to achieve an extremely stable output free from the annoying effects of line voltage and load current fluctuations.

Additional features include an instant resetting anti-overshoot circuit to positively prevent output voltage overshooting the pre-set level under all conditions of start-up, shut-down, temporary power failure, etc.

Calibrated voltage controls accurate to .5% provide setting output voltage to any desired level with a resolution of 10 millivolts.

Special models of the 405 can be furnished for fixed voltage and fixed polarity applications. They can be supplied without output voltage controls, polarity switch or meter. Where the application of the supply is such that it may be affected by environmental conditions such as dust, dirt, sand, etc., the Model 405F is recommended. The Model 405F is a totally enclosed unit equipped with blower and dust filter.

SPECIFICATIONS

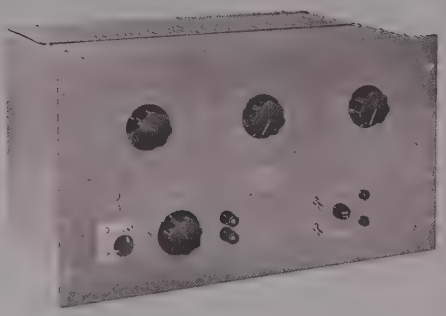
Input Voltage:	117 volts, 50/60 cycles, single phase. Can be supplied for 234 volts, 50/60 cycles.
Output Voltage:	600 to 3110 volts dc
Output Current:	0 to 15 milliamperes dc
Output Polarity:	Positive or negative with respect to chassis, selected via front panel switch
Monitoring Output:	1.02 volt sample for potentiometric monitoring at front panel binding posts.
Connectors:	See page 15.
Regulation vs. Line:	.01% maximum for line voltage variation from 105 to 130 volts.
Regulation vs. Load:	.005% for 10MA load change.
Stability:	.005% per hour, .05% per day after warmup.
Ripple & Jitter:	Less than 5MV RMS at any output voltage and current in either polarity.
Voltage Calibration:	2 -1000 volt steps 1 - 400 volt step 10- 100 volt steps 10- 10 volt steps 1 - 10 volt vernier
Voltage Resolution:	10 millivolts at any output voltage.
Calibration Accuracy:	Better than .5%.
Size:	19" W x 10½" H x 14" D. Slotted to RMA standards. Equipped with resilient feet for bench use.
Net Weight:	49 pounds.
Shipping Weight:	63 pounds.
Finish:	Smooth grey, baked enamel. Panel machine engraved.
Price:	Model 405. $595.00 F.O.B. Factory, Seattle, Washington. Model 405F. $635.00 F.O.B. Factory, Seattle, Washington.

HIGH VOLTAGE

High Resolution Nuclear Power Supply

MODEL 400BDA

500 TO 5100 VOLTS



FEATURES

- 500 to 5100 VOLTS OUTPUT
- TO 1 MILLIAMPERE
- ELECTIVE OUTPUT POLARITY
- BSOLUTE FREEDOM FROM JITTER
- NEGLIGIBLE RIPPLE (5 MV MAX.)
- .01% LINE REGULATION
- .01% LOAD REGULATION
- EXCELLENT LONG TERM STABILITY

The Model 400BDA is an extremely stable, highly regulated source of DC voltages in the range of 500 to 5100 volts. Careful attention to component selection and circuit layout and very conservative transformer design and assembly procedures have resulted in a noise free DC output instantly reversible in polarity by a simple front panel switch. The complete freedom from arcing jitter, bounce, and corona make the Model 400BDA the logical first choice for the exacting requirements of photomultiplier, proportional counter and ionization chamber work.

The Model 400BDA employs a high gain regulator system wherein a portion of the output voltage is compared with a reference voltage and the error amplified and applied to a special high mu series passing tube to effect correction. Selection of the sample portion is accomplished by a precision wire wound resistor network and the reference voltage is derived from type 5651 reference tubes operated at constant current from a .05% regulated auxiliary supply. The comparison element is a stabilized dual triode operated as a differential amplifier. Feedback systems are employed to reduce ripple and output impedance to a minimum.

A switch with pilot light is provided for removing high voltage from the output connector while leaving the supply in standby condition. A 1.02 volt sample of the output voltage is made available at a pair of front panel binding posts for potentiometric monitoring of the output. Calibrated output voltage controls accurate to .5% provide for setting output voltage to any desired level with a resolution of 50 millivolts.

SPECIFICATIONS

Input Voltage:	117 volts, 50/60 cycles, single phase. Can be supplied for 234 volts, 50/60 cycles.
Input Power:	65 watts fully loaded.
Output Voltage:	500 to 5100 volts.
Output Current:	0 to 1 milliampere.
Output Polarity:	Positive or negative with respect to chassis, selected by front panel switch.
Output Connector:	See page 15.
Regulation vs. Line:	.01% maximum from 100 to 130 line volts.
Regulation vs. Load:	.01% maximum, no load to full load.
Stability:	Better than .005% per hour, .05% per day after warmup.
Ripple:	5 millivolts maximum at any output voltage and current in either polarity mode.
Voltage Calibration:	4-1000 volt steps. 1-500 volt step. 10-100 volt steps. 1-100 volt calibrated vernier.
Voltage Resolution:	50 millivolts at any output setting.
Calibration Accuracy:	Better than .5%.
Size:	19" W x 10½" H x 12½" D. Slotted to RMA standards. Equipped with resilient feet for bench use.
Net Weight:	42 pounds.
Shipping Weight:	56 pounds.
Price:	$595.00 F.O.B. Factory, Seattle, Washington

400 BDB

HIGH VOLTAGE NUCLEAR SUPPLY

1000-6100 VDC

The Model 400BDB is identical to the Model 400BDA with the following exceptions:

Output Voltage:	1000-6100 Volts DC.
Output Current:	0 to 250 microamperes.
Voltage Calibration:	5-1000 volt steps. 10-100 volt steps. 1-100 volt vernier.
Price:	$595.00 F.O.B. Factory, Seattle, Washington

PRECISION DIFFERENTIAL VOLTMETER

MODEL 800

FEATURES

- 0 to 500 Volts DC
- Infinite Input Resistance at Null
- Accuracy .05% of Actual Reading
- Standard Cell Reference
- Resolution .01 Volt Directly from Calib. Controls
- Search Range for Rapid Voltage Approximation
- Multipliers Available for use to 5KV

PRECISE DC VOLTMETER WITH INFINITE INPUT RESISTANCE

The Model 800 Differential DC Voltmeter is an electronic instrument for the precise measurement of DC voltages. It is a true potentiometer and permits the rapid measurement of DC voltages up to 500 volts to an accuracy of .05%, with absolutely no source loading. A convenient 500-0-500 volt "search" range with 10 megohms input resistance is provided for quickly locating the unknown voltage in the 500 volt spectrum prior to the .05% measurement in the differential mode. Two calibrated burn-out proof null ranges of 10 and 1 volt full scale sensitivity provide excellent resolution and permit observation of voltage excursions in the source under measurement. The Model 800 Differential Voltmeter utilizes printed circuits and aluminum construction throughout to achieve a light weight, rugged and modern portable instrument for rapid accurate measurement of DC voltages on production and test lines, in the laboratory and in the field. A mirror scale meter using sapphire, spring-mounted pivots facilitates precise nulling.

SPECIFICATIONS

Input Voltage:	117 volts, 50/60 cycles single phase. Can be supplied for 234 volts, 50/60 cycles.
Voltage Range:	0 to 500 volts DC.
Input Resistance:	Infinite at null as indicated by zero deflection of the meter. 2000 megohms per volt of input voltage for 0.005 volt unbalance as indicated by meter.
Scales:	1-0-1 volt DC. 10-0-10 volts DC.
Accuracy:	.05% of actual voltage from 10 to 500 volts. .1% of actual voltage, or 5 mv, whichever is greater, below 10 volts.
Resolution:	0.01 volt read directly on calibrated controls. Greater resolution available by reading meter.
Size:	Cabinet Model: 9¾" W x 13" x 14" D. Rack Model: 19" W x 8¾" H x 16¾" D.
Finish:	Smooth grey panel. Grey baked wrinkle case.
Net Weight:	Cabinet: 20 pounds. Rack: 20 pounds.
Shipping Weight:	Cabinet: 27 pounds: Rack: 34 pounds.
Price:	Cabinet Model: $355.00 F.O.B. Factory, Seattle, Washington. Rack Model: $355.00 F.O.B. Factory, Seattle, Washington

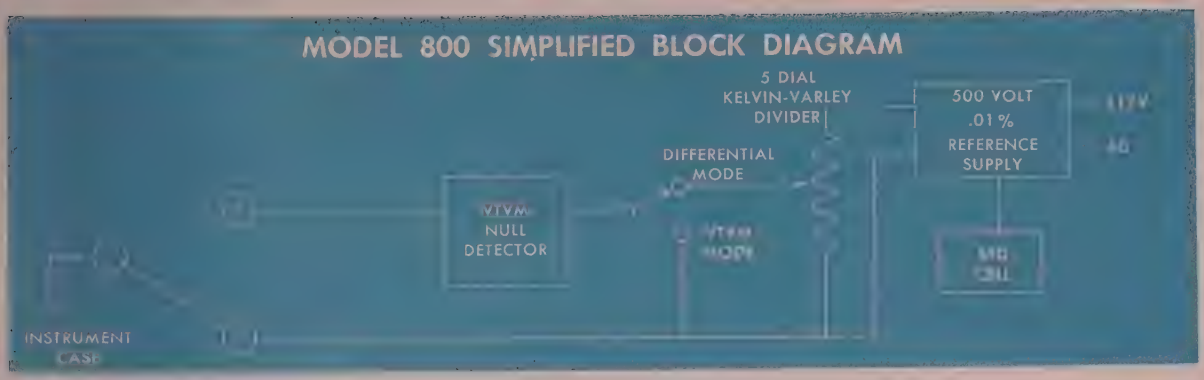
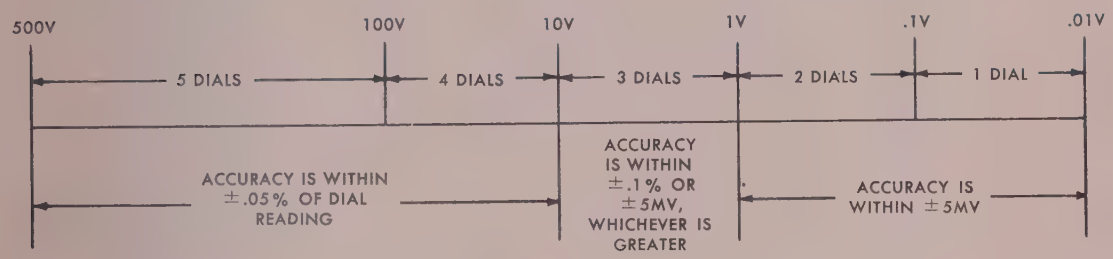


FIG. 1



This diagram shows the limits of accuracy and the number of dials (Kelvin-Varley divider) in use as a function of input voltage

FIG. 2

MODEL 800R

Precision Potentiometric DC Voltmeter

MODEL 801

FEATURES

- Accuracy .05% of input voltage from 500 to .1 volt
- Four potentiometric ranges
- Infinite input resistance at null
- Eight search and VTVM ranges
- Standard Cell Reference
- Automatic lighted decimal for fast, direct read-out

The Model 801 Precision Potentiometric DC Voltmeter is a sensitive, highly accurate true potentiometer. It is self contained, portable, and virtually impossible to damage by accidental overload. Basic elements of the 801 are a standard cell, an extremely stable 500 volt reference source, a precision five-dial Kelvin-Varley voltage divider and a chopper stabilized null detector.

In order to set the reference voltage with high accuracy, the standard cell comparison circuit is factory-set precisely to the actual standard cell voltage available in each instrument. This procedure eliminates resistor tolerances in the comparison circuit. The same approach is used in the decade dividers resulting in these strings having an accuracy of better than .01%. Resistors on the five Kelvin-Varley dials are matched to each other and, in turn, the completed dials are matched units. The chopper-stabilized null detector in the Model 801 has exceptionally high stability allowing true null to be determined accurately. This stability plus the four ranges of the detector further insure accuracy and ease of operation.

SPECIFICATIONS

AS A PRECISION POTENTIOMETER

RANGES:

Input Voltage Range	*Null Voltage Ranges	Input Resistance per volt of input voltage At Null	1% Off Null
50-500	10-0-10	Infinite	100 Meg
	1-0-1	Infinite	1000 Meg
5-50	1-0-1	Infinite	1000 Meg
	.1-0-.1	Infinite	1000 Meg
.5-5	.1-0-.1	Infinite	1000 Meg
	.01-0-.01	Infinite	10000 Meg
0-.5	.1-0-.1	Infinite	1000 Meg
	.01-0-.01	Infinite	10000 Meg

*Any null range may be used with any input voltage range; recommended ranges are shown above.

ACCURACY: ± .05% of input voltage from .1V to 500V; below .1V ± .1% of input voltage or .00005V whichever is greater.

RESOLUTION:

Input Voltage Range	Dial Limits Volts	Meter Limits on Rec. Null Range Volts
50-500	.01	.005
5-50	.001	.0005
.5-5	.0001	.00005
0-.5	.00001	.00005

AS A VACUUM TUBE VOLTMETER

Voltage Ranges: ±500, ±50, ±5, ±.5 and ±10*, ±1*, ±.1*, ±.01* volts dc full scale.
*These ranges obtained by setting null range to desired sensitivity and five voltage dials to zero.

Input Resistance: 10 megohms for all voltage ranges except .1 and .01 which have 1 megohm input resistance.

Accuracy: ±4% of full scale value.

GENERAL FEATURES

Stability of Reference: ±.01% for 25% change in line voltage.

Settability of Reference: ±.01% per hour after 30 min. warm up.
Reference supply can be set to 500 volts ±.01% or better against built-in standard cell.

Stability of Meter Reading: 4% of full scale for 25% change in line voltage.

Input Voltage: 117 volts, 50/60 cycles, single phase. Can be supplied for 234 volts, 50/60 cycles.

Size: Cabinet Model: 9¾" W x 13" H x 14" D.
Rack Model: 19" W x 8¾" H x 16¾" D.

Net Weight: Cabinet Model: 22 pounds.
Rack Model: 21 pounds.

Shipping Weight: Cabinet Model: 29 pounds.
Rack Model: 35 pounds.

Price: Cabinet Model: $485.00 F.O.B. Factory, Seattle, Washington
Rack Model: $485.00 F.O.B. Factory, Seattle, Washington

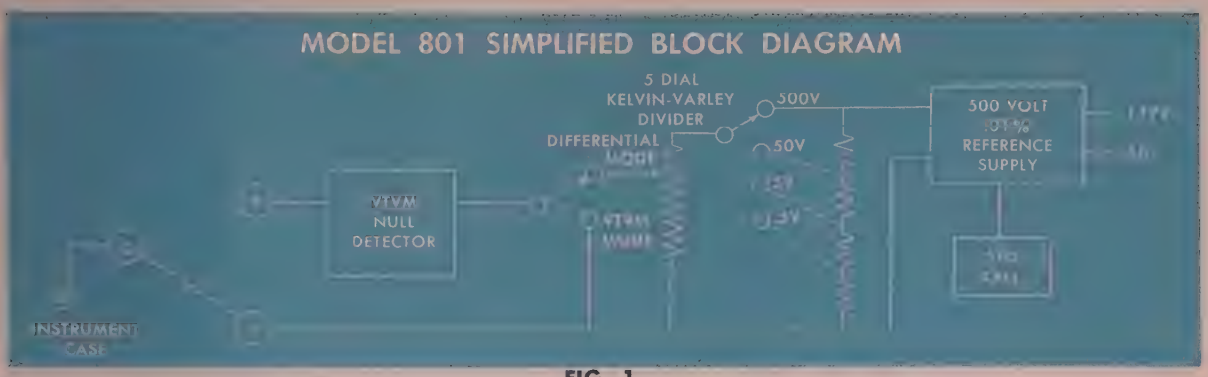
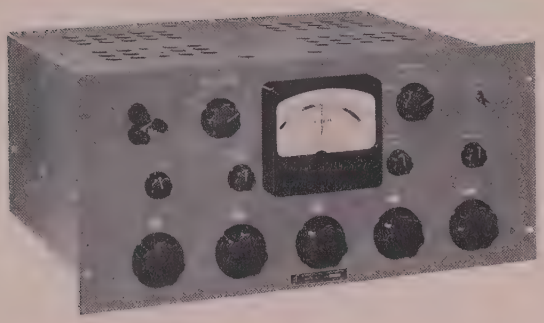
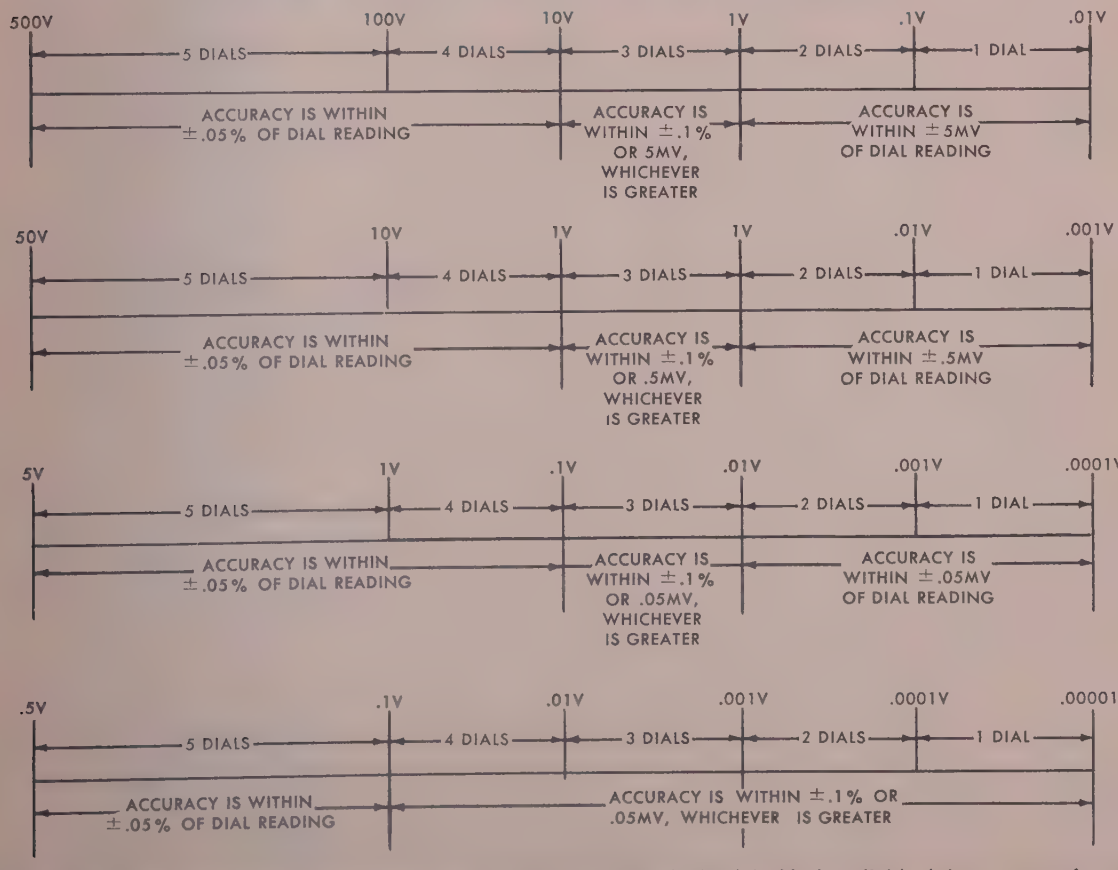


FIG. 1

MODEL 801R



MODEL 801 — ACCURACY VS INPUT VOLTAGE



This diagram shows the limits of accuracy and the number of dials (Kelvin-Varley divider) in use as a function of input voltage.

FIG. 2

Precision DC-AC Differential Voltmeter

MODEL 803

FEATURES

DC
- Accuracy .05% of input voltage
- Four search ranges and four null sensitivities
- Infinite input resistance at null

AC
- Accuracy .2% of input voltage
- Converter frequency response 30 cps to 5 kc
- Measures RMS value of true sine wave

- DIRECT IN-LINE READOUT
- STANDARD CELL REFERENCE
- AUTOMATIC LIGHTED DECIMAL

The Model 803 DC-AC Precision Differential Voltmeter is a compact, highly accurate, portable voltmeter designed for precision measurement of DC or AC voltages. Ease of operation and inherent protection from accidental overload, combined with high accuracy and resolution, assure equal suitability for production line testing or precision laboratory measurements. The instrument may be used as a vacuum tube voltmeter, as a differential DC voltmeter, or as a differential AC voltmeter. No delay is encountered when switching from one type of measurement to another. The front panel controls are arranged so that all measurements involve simple, systematic adjustment of the controls. The value of the unknown voltage is directly displayed on an in-line read-out—complete with an automatically lighted decimal point. It is possible to make precise measurements of a stable voltage, or to observe and measure relatively slow excursions about an average level of voltage. Highest quality components conservatively rated are employed throughout, insuring stable, trouble-free operation. Basic elements of the 803 are a standard cell, a 500 volt reference source and precision decade divider, a chopper stabilized null detector and an extremely stable DC to AC converter. Connection of these is shown, in simplified form, in the block diagram.

SPECIFICATIONS

AS A DIFFERENTIAL VOLTMETER

VOLTAGE RANGES:

	Input Voltage Range	Recommended Null Range	Input Impedance At Null	Input Impedance 1% Off Null
DC	50-500	10-0-10	INFINITE	100M
		1-0-1	"	1000M
	5-50	1-0-1	"	1000M
		.1-0-.1	"	1000M
	.5-5	.1-0-.1	"	1000M
		.01-0-.01	"	1000M
	0-.5	.1-0-.1	"	10000M
		.01-0-.01	"	10000M
AC	50-500	10-0-10	1M, 25 uuf	1M, 25 uuf
		1-0-1	"	"
	5-50	1-0-1	"	"
		.1-0-.1	"	"
	.05-5	.1-0-.1	"	"
		.01-0-.01	"	"

RESOLUTION:

	Input Voltage Range	Dial Resolution (Volts)	Meter Resolution (Volts)
DC	50-500	.01	.005
	5-50	.001	.0005
	.5-5	.0001	.00005
	0-.5	.00001	.00005
AC	50-500	.01	.005
	5-50	.001	.0005
	.05-5	.0001	.00005

ACCURACY:

DC ± .05% OF INPUT VOLTAGE FROM .1 TO 500V
± .1% OF INPUT VOLTAGE OR .00005V, WHICHEVER IS GREATER FROM 0 TO .1V

AC ± .2% OF INPUT VOLTAGE FROM .5 TO 500V, REDUCED ACCURACY FROM .05 TO .5V

AS A VACUUM TUBE VOLTMETER

VOLTAGE RANGES:

	Input Voltage Range	Input Impedance
DC	± 500	10M
	± 50	10M
	± 5	10M
	± .5	10M
	± 10 *	10M
	± 1 *	10M
	± .1 *	1M
	± .01 *	1M
AC	0-500	1M, 25 uuf
	0-50	"
	0-5	"
	0-100 *	"
	0-10 *	"
	0-1 *	"
	0-.1 *	"
	0-.01 *	"

*Using Null Ranges

GENERAL SPECIFICATIONS

REFERENCE STABILITY:
± .01% FOR 25% CHANGE IN LINE VOLTAGE
± .01% PER HOUR AFTER 30 MINUTE WARMUP

AC TO DC CONVERTER FREQUENCY RESPONSE:
30 CPS TO 5000 CPS

INPUT POWER: 175 WATTS AT 117/234 VOLTS, 50/60 CYCLES

SIZE: CABINET MODEL—13" H x 9¾" W x 16" D

NET WEIGHT: CABINET MODEL—30 POUNDS

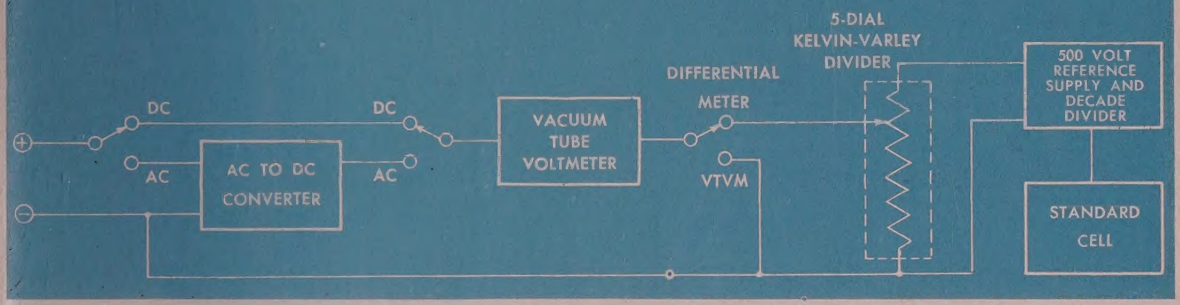
SHIPPING WEIGHT: CABINET MODEL—38 POUNDS

PRICE: $845.00 F.O.B. FACTORY, SEATTLE, WASH.

MECHANICAL FEATURES

Careful mechanical design consideration was given to provide convenient accessibility to all circuit components. Substantially all circuitry is in printed form. The printed circuit boards are arranged so that their circuit sides are accessible simply by removing the instrument case. Key printed circuit boards are the plug-in type and may be readily removed to gain access to internal components. The front panel may be swung open when the case is removed, providing access to the precision components located near the front of the instrument. All calibration adjustments may be made without removing the instrument from the case.

BASIC BLOCK DIAGRAM



ACCESSORIES

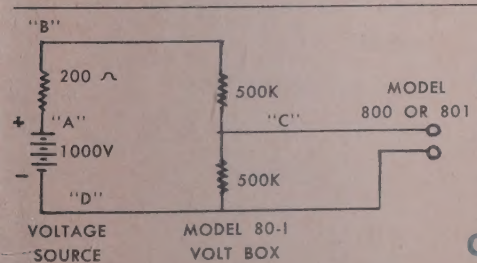
MODEL 80 VOLT BOXES

Both the Model 800 and the Model 801 differential voltmeters may be used to measure voltages in excess of 500 volts by using an appropriate voltage divider or "volt box" to attenuate the EMF under measurement to 500 volts or less.

The three chief requirements of a voltage divider or "volt box" for use with the Models 800 and 801 are extreme accuracy of the division ratio, very low temperature coefficient of resistance, and excellent long term stability. The last two requirements automatically rule out all composition, deposited carbon and metal film resistors. The only type suitable is a properly aged precision wire-wound unit wound with Evanohm or equivalent alloy.

The John Fluke Mfg. Co. has made available a series of volt boxes which meet the above requirements. These are the Model 80 series, and a list of the ranges available follows:

MODEL NO.	DIVISION RATIO	MAXIMUM INPUT	TOTAL RES.	CURRENT DRAWN AT MAX. INPUT	PRICE
80-1	2:1	1 KV	1 megohm	1 MA	$ 60
80-2	4:1	2 KV	2 megohms	1 MA	70
80-3	6:1	3 KV	3 megohms	1 MA	80
80-4	8:1	4 KV	4 megohms	1 MA	90
80-5	10:1	5 KV	5 megohms	1 MA	100
80-6	2:1	1 KV	10 megohms	0.1 MA	120

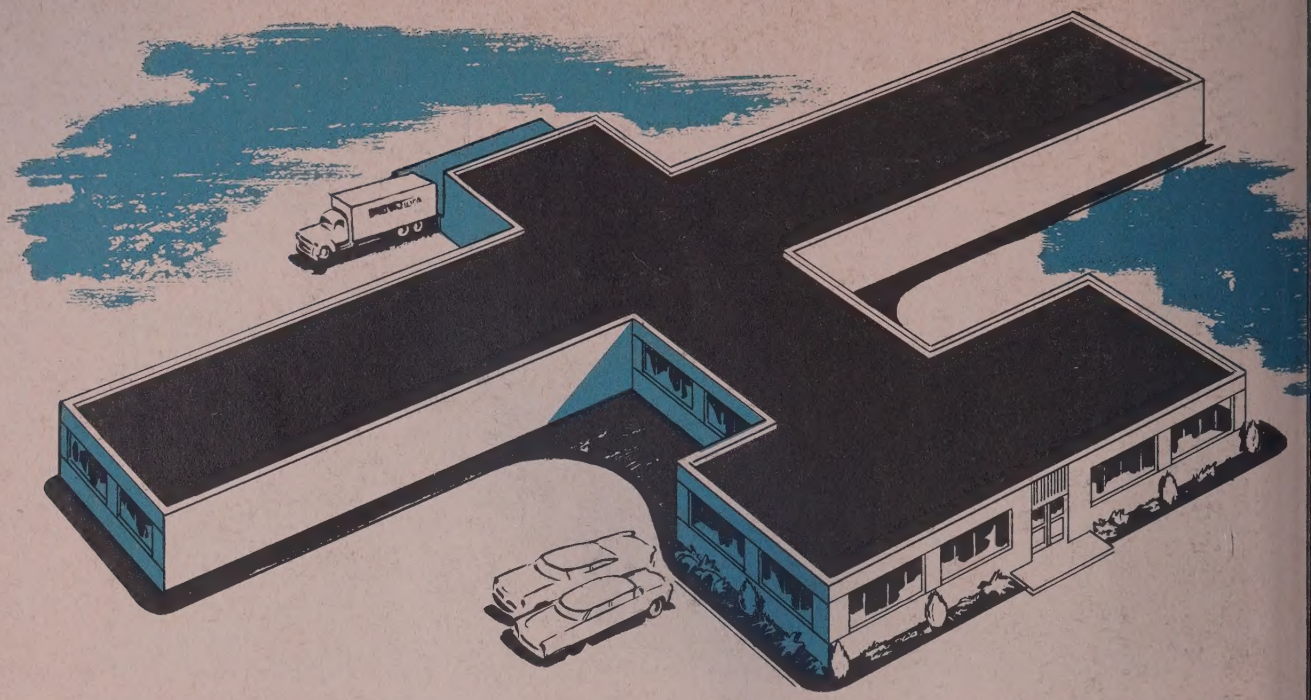


The division ratio of all models is accurate to .01% and long term stability is better than .01% per year. All models are housed in black phenolic boxes measuring 5¼" wide x 6¾" long x 2¼" deep. Output terminals are General Radio polystyrene on ¾" centers, and the input is brought out by a pair of 6-foot flexible leads. The "hot" lead is made of a special high voltage wire insulated for better than 10 KV.

CONNECTORS

All high voltage power supplies, with the exception of the jf Model 409, are provided with 2 each AN-3102-18-16S connectors, one on front panel, one on rear skirt. One mating connector is furnished with each instrument at no additional charge. Special connectors available on request.

The Model 409 is provided with 2 each UG/931-U connectors, one on front panel, one on rear skirt. One mating connector furnished at no additional charge. Special connectors are available for this instrument; however, choice is limited to connector on rear skirt only.



The John Fluke Manufacturing Co., Inc. has chosen competent, independent representative organizations who specialize in instrumentation and applications. Below is a list of these companies who are at your disposal for discussion or demonstrations of our equipment.

UNITED STATES AND CANADIAN REPRESENTATIVES

ALBUQUERQUE, NEW MEXICO
Gene French Company
120 San Pedro S. E.
Albuquerque, New Mexico

ATLANTA, GEORGIA
Bivens & Caldwell, Inc.
3133 Maple Drive N. E.
Atlanta 5, Georgia

BALTIMORE, MARYLAND
Horman Associates, Inc.
3006 W. Cold Spring Lane
Baltimore 15, Maryland

BOSTON, MASSACHUSETTS
Technical Instruments, Inc.
90 Main Street
Reading, Massachusetts

BRIDGEPORT, CONNECTICUT
Technical Instruments, Inc.
1115 Main Street
Bridgeport, Connecticut

CHICAGO, ILLINOIS
Cozzens & Cudahy, Inc.
845 Chicago Avenue
Evanston, Illinois

CLEVELAND, OHIO
M. P. Odell Company
26614 Center Ridge Road
Westlake, Ohio

DALLAS, TEXAS
Wallace-Gluck Company
P. O. Box 13203
Dallas 20, Texas

DAYTON, OHIO
M. P. Odell Company
2676 Salem Avenue
Dayton, Ohio

DENVER, COLORADO
Gene French Company
3395 South Bannock Street
Englewood, Colorado

DETROIT, MICHIGAN
M. P. Odell Company
10531 W. McNichols Road
Detroit 21, Michigan

HARTFORD, CONNECTICUT
Technical Instruments, Inc.
119 Ann Street
Hartford, Connecticut

HIGH POINT, NORTH CAROLINA
Bivins & Caldwell, Inc.
P.O. Box 5187
High Point, North Carolina

KANSAS CITY, MISSOURI
Harris-Hanson Co.
7916 Paseo Avenue
Kansas City 30, Missouri

LOS ANGELES, CALIFORNIA
McCarthy Associates, Inc.
1055 East Walnut Street
Pasadena, California

MINNEAPOLIS, MINNESOTA
Pinkney & Hine Company
1925 Nicollet Avenue
Minneapolis 3, Minnesota

NEW YORK, NEW YORK
G. Curtis Engel & Associates
210 South Broad Street
Ridgewood, N. J., RE 2-0001

ORLANDO, FLORIDA
Bivins & Caldwell, Inc.
P. O. Box 6025, Tel: CH 1-1091
Orlando, Florida

PHILADELPHIA, PENNSYLVANIA
G. Curtis Engel & Associates
P. O. Box 4383, WAlnut 2-3270
Philadelphia 18, Pennsylvania

PITTSBURGH, PENNSYLVANIA
M. P. Odell Company
750 Penn. Avenue
Pittsburgh 21, Pennsylvania

RIDGEWOOD, NEW JERSEY
G. Curtis Engel & Associates
210 South Broad Street
Ridgewood, New Jersey

SAN DIEGO, CALIFORNIA
McCarthy Associates, Inc.
934 W. Laurel Street
San Diego 1, California

SAN FRANCISCO, CALIFORNIA
McCarthy Associates, Inc.
635 Oak Grove Avenue
Menlo Park, California

SEATTLE, WASHINGTON
Rush S. Drake Associates
1806 Bush Place
Seattle 44, Washington

ST. LOUIS, MISSOURI
Harris-Hanson Company
2814 S. Brentwood Blvd.
St. Louis 17, Missouri

SYRACUSE, NEW YORK
J. D. Ryerson Associates, Inc.
P. O. Box 1400
Syracuse 1, New York

TORONTO, ONTARIO, CANADA
The Glendon Company, Ltd.
44 Wellington Street East
Toronto 1, Ontario, Canada

VANCOUVER, B.C., CANADA
Rush S. Drake Associates
1806 Bush Place
Seattle 44, Washington

WASHINGTON, D. C.
Horman Associates
941 Rollins Avenue
Rockville, Maryland

EXPORT REPRESENTATIVES

AD Auriema, Inc.
85 Broad Street
New York 4, New York
Africa, Australia, France, Great Britain, Indonesia, Ireland, Israel, Italy, Japan, Mexico, New Zealand, Portugal, Scotland, South and Central America, Spain.

Berg-Hedstrom & Co., Inc.
1170 Broadway, New York 1, New York
Cable address: JONSTROM
Belgium, Denmark, Finland, Germany, Holland, Norway, Sweden, Switzerland.

The right is reserved, without notice, to make such changes in equipment, design, or components as engineering or manufacturing progress may warrant.

Prices subject to change without notice.

METROPOLITAN AND WESTERN LITHO IN U.S.A.

Form No.

www.manualsplus.com
1020777